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DELVE

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DELVE

Restructuring Demining rEsearch from Regional initiatives within Europe

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Executive Summary

This document summarizes the analysis of the Humanitarian Demining RTD situation from early 1990 until today. Four European countries (Belgium, Germany, The Netherlands and the United Kingdom) were selected together with Japan. The situation at the European level was also analysed, with emphasis on activities sponsored by the European Commission.

The study team have taken a number of approaches in carrying out this analysis. The team started from the existing body of literature and contacts accumulated from its extensive participation to European and national R&D programmes in the past decade, complemented where necessary with targeted literature surveys (documents, databases, and internet search). A number of direct contacts and where appropriate interviews were used for the selected countries, both to compile the detailed descriptions of the most important national activities, and to complement our analysis. Representative events, organisations and projects were selected rather than seeking to be exhaustive.

This document provides:

- An analysis of the key events in Mine Action in the form of timelines, as well as of the key players in Humanitarian Demining RTD and Mine Action and their main interactions.
- A detailed analysis of the RTD situation in selected European countries as well as at the European Commission level.
- An illustration of some success stories in bridging the gap between RTD and field deployment.
- A basis for the analysis of lessons learned in D4.2 – “Humanitarian Demining R&D Lessons Learned”.

What emerges from the following overviews is that:

- Humanitarian Demining activities started in earnest during the late '80s-early '90s and soon made the headlines thereafter. As one of the consequences important RTD efforts were started, including a strong EC R&D civilian programme.
- Different countries replied in very different ways (research fragmentation at the European and national level - fragmentation aspects are discussed in D4.2 – “Humanitarian Demining R&D Lessons Learned”).
- In a number of cases there has been little interaction between decision makers, R&D organisations and/or end users.
- As with many other “new” topics all involved actors had to climb their share of the learning curve, new structures and ways of collaborating had to be invented (e.g. the International Test and Evaluation Programme, ITEP), with mixed success.
- Examples of coordinated *end-to-end planning* by creating coherence between (1) policy, based on political decision, (2) RTD, testing and production of equipment, and (3) timely deployment, supported by a well organised and co-ordinated organisational structure, showed effectiveness in bridging the gap between R&D and Deployment.
- From the review of the EC R&D projects it appears that, at the current funding/project size, the typical timeframe of 2-3 years is very short for R&D projects, which include a requirements phase, a specification phase, development and integration, demonstrator building, laboratory testing and initial field tests by end users, to be effective. Currently the timeframe for R&D is not sufficiently synchronised with the timeframe of Humanitarian Action funding/operation.

- At the humanitarian demining sensing related R&D level, the most notable developments which have taken place during the past 10 years are: "(i) an increased understanding of the problem, (ii) a shift from a focus on the individual sensor as a solution towards the individual sensor as part of a set of tools, (iii) an increased emphasis on area reduction and the detection of minefield indicators rather than individual mines, (iv) an increased emphasis on trace explosive detection, (v) the gaining of importance of systematic test and evaluation (in particular via the International Test and Evaluation Programme, ITEP)" [BRU2006].
- Although a host of physical principles have been investigated to detect landmines, only electromagnetic-based technologies, in particular enhanced metal detectors and ground penetrating radars, have seen significant advances and are being introduced into the field. Test results consistently confirm that some of these technologies can indeed increase the productivity of humanitarian demining, while at least maintaining the current high levels of safety. Several development groups have shown this is the case for the combination of a metal detector with ground penetrating radar.
- Well known demonstrator systems developed using Earth Observation techniques (e.g. the DG Development Pilot project: Airborne Minefield Detection in Mozambique, and the DG IST ARC & SMART projects) have been sufficiently demonstrated, together with their cost/benefit potential; however, their take-up by end users has not been successful.
- Information Technology, including GIS, has been demonstrated in several European projects (e.g. the DG IST ISIS "Intelligent Systems for Humanitarian Geo-Infrastructure" project, and the DG Development MINEDEMON "Mine Database Demonstrator" project), as well as national projects (RMA-Belgium Paradis). However, the deployment of such systems for field use has been achieved by the GICHD with its Information Management System for Mine Action (IMSMA), and by the Swedish EOD and Demining Centre (SWEDEC) with its EOD IS system, using the end-to-end planning approach mentioned above.
- At the R&D level the subject started to lose importance as from around 2004, being mostly taken over by security related issues and environmental risk management as a whole. The current reduction of the EU Humanitarian Demining research programme and its incorporation into the wider "Improving Risk Management" strategic objective, which was foreseen as a way of generating synergies with other types of responses to humanitarian crises management, where technologies such as Information Management, Geographical Information Management and Earth Observation are more likely to be used in a 'System Approach', did not generate the expected synergies.
- Military R&D efforts are still ongoing, although refocused around specific topics (e.g. MMSR-SYDERA in Germany), and likely to continue for the foreseeable future.
- On the civilian front some individual, mostly academic efforts are still ongoing at national level, whereas large concerted projects are ending – like for European projects – and might not be continued.
- Mine Action funding is mostly levelling off, including at EC level, but not decreasing and still substantial [ICBL2006, pp. 64-72].

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1.0.0	27/04/07	Draft Version issued to EC		
2.0.0	18/5/2007	Final completely revised version including reviewers' comments		
2.1.0	13/6/2007	Final document revision and minor corrections		

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1 INTRODUCTION

1.1 Document Overview

This document summarizes the analysis of the Humanitarian Demining RTD situation from early 1990 until today. It provides:

- An analysis of the key events in Mine Action in the form of timelines, as well as of the key players in Humanitarian Demining RTD and Mine Action and their main interactions.
- A detailed analysis of the RTD situation in selected European countries as well as at the European Commission level.
- An illustration of some success stories in bridging the gap between RTD and field deployment.
- A basis for the analysis of lessons learned in D4.2 – “Humanitarian Demining R&D Lessons Learned”.

The study team have taken a number of approaches in carrying out this analysis. The team started from the existing body of literature and contacts accumulated from its extensive participation to European and national R&D programmes in the past decade, complemented where necessary with targeted literature surveys (documents, databases, and internet search). A number of direct contacts and where appropriate interviews were used for the selected countries, both to compile the detailed descriptions of the most important national activities, and to complement our analysis. Representative events, organisations and projects were selected rather than seeking to be exhaustive.

This document is structured as follows:

- **Section 2** Defines the key players in Humanitarian Demining RTD as well as in Mine Action.
- **Section 3** Presents a deep analysis of the RTD situation in selected European countries and Japan, as well as at the European Commission level.
- **Section 4** Summarizes the findings of a bibliometric study with respect to HD RTD.
- **Section 5** Illustrates some success stories in bridging the gap between RTD and field deployment.
- **Section 6** Draws some conclusions.
- **Section 7** Lists the main used bibliography.
- **Annex-A** Describes the state of the art of the main sensing technologies investigated for Humanitarian Demining applications, some of which are referred to in this document.
- **Annex-B & Annex-C** Summarize the DELVE Data Base & Website concepts as well as the list of Organizations dealt with, within the context of this study.

1.2 Applicable and Main Reference Documents

[DoW]	Description of Work. EC IST, <i>DELVE</i> .
[RevDoW]	Revised Description of Work. EC IST, <i>DELVE</i> .
[D3.1]	Organizational Aspects Intermediate Report
[D4.2]	Humanitarian Demining R&D Lessons Learned

Table 1-1 Applicable documents

[BRU2006]	C. Bruschini, H. Sahli, A. Carruthers, "Guidebook on Detection Technologies and Systems for Humanitarian Demining", Geneva International Centre for Humanitarian Demining, ISBN 2-88487-045-8, Geneva (2006). www.gichd.ch and http://www.gichd.ch/1248.0.html
[GAS2005]	R. Gasser, R. Keeley, "Global Assessment of EC Mine Policy and Actions 2002-2004", Framework Contract: EUROPEAID/116548/C/SV, LOT Number 4 Mission number 2004/89069 - Version 2, March 2005. http://ec.europa.eu/europeaid/projects/mines/global_assessment_final.pdf
[GAS2004]	R. Gasser, "EC research and the deployment gap", presentation at the EUDEM2 Final Workshop, 5/10/2004, Brussels. http://www.eudem.vub.ac.be/eudem2_final_workshop_programme.htm
[GAS2003]	R. Gasser, "Report on Expert Panel Meeting on Humanitarian Demining RTD", Brussels, 20/3/2003, unpublished.
[EC2003]	"Humanitarian Demining Research and Technological Development funded by the European Commission", Brochure, European Commission, Publication EUR 20830, ISBN 92-894-5942-5, 2003. http://serac.jrc.it/publications/pdf/demining_no_sig_en.pdf
[COR2004]	J. Cornelis, H. Sahli, "International Conference Assembles Military Considerations within Mine Action Technology Trends", Journal of Mine Action, Issue 8.1, June (2004), p. 63. http://maic.jmu.edu/ .
[COR2003]	J. Cornelis, H. Sahli, "International Conference on Requirements and Technologies for the Detection, Removal and Neutralization of Landmines and UXO" (EUDEM2-SCOT 2003 - VUB, Brussels, 15-18 September 2003) - Trends, generic conclusions, open questions, 12/12/2003. http://www.eudem.vub.ac.be/eudem2-scot/
[COR2000]	J. Cornelis, A. Craib, R. Voles, "Strategic Study of the Humanitarian Demining Prospects - The role of RT&D analysed as a Europe-wide issue", 30/5/2000. http://www.eudem.vub.ac.be/publications/Files/StrategicStudy.pdf

Table 1-2 Main Reference documents

2 KEY PLAYERS AND STAKEHOLDERS IN DEMINING AND DEMINING RESEARCH

This section summarizes the key players in Humanitarian Demining (HD) and related RTD as well as their interaction.

2.1 Identification of Main Groups

The key players and stakeholders in Humanitarian Demining related R&D have been identified on the basis of DELVE's first year project task, namely *Overview of Organisational Aspects*. The aim of the overview has been to identify the major European players in terms of Research & Development as well as the main R&D donors, and the inter-relationship between national institutions. The outcome of the study has been reported in D3.1 "Organizational Aspects – Intermediate Report". The study has been refined during the second phase of the DELVE project, based on the focus of the analysis on four European countries, namely Belgium, Germany, The Netherlands and the United Kingdom. Moreover, the general situation at the European level has been assessed. A non-European country, Japan, has also been considered as a test case for this study.

In order to facilitate the analysis in D4.2- "Humanitarian Demining R&D Lessons Learned" we have structured the key players into the following three main groups (see Figure 2-1):

- **Donors/Decision makers:** these do actually include well separated entities such as:
 - Civilian, R&D oriented (e.g. DG INFSO, or national research foundations),
 - Civilian, end user oriented (such as Foreign Affairs or Development Aid ministries),
 - Defence oriented (Ministries of Defence and/or their Procurement Agencies).
- **R&D organisations** (academic, defence, R&D centres, large industry, SME, other), with usually well separated interests, and
- **End users** (in Humanitarian Demining as well as military).

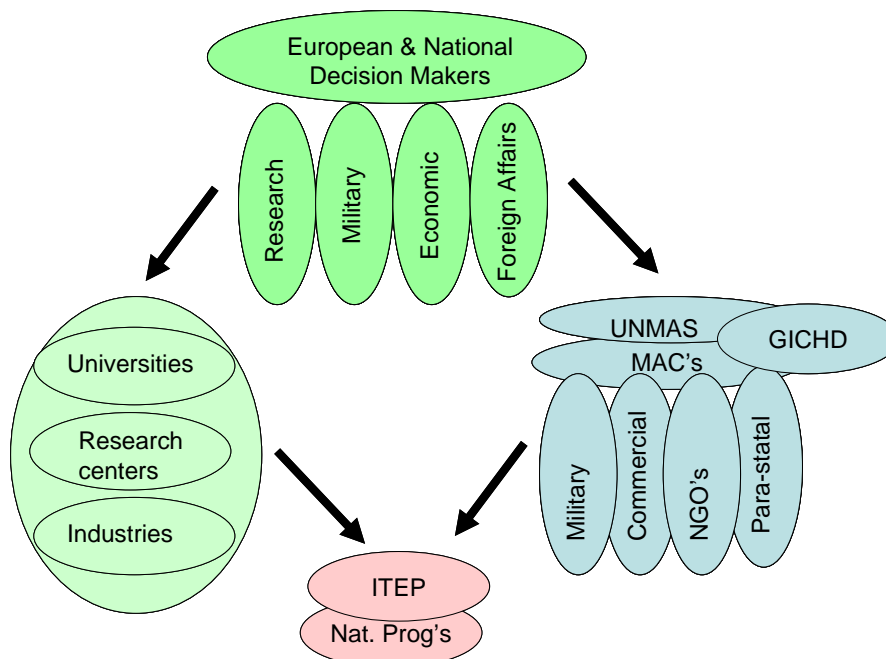


Figure 2-1 Key Players Structure

Their main activities, and roles in the HD R&D context, are detailed in Table 2-1 below.

Category Type	Example(s)	Main activities	Role (in HD R&D context), Comments
Donors/Decision Makers Civilian, R&D oriented	National research funding bodies EC: DG INFSO	Decide RD policy and fund R&D activities, in general not specifically linked to HD	National: support of individual R&D projects, sometimes larger consortia. EC: support to a large civilian HD R&D programme.
Civilian, end user oriented	Foreign Affairs, Development Aid ministries EC: DG RELEX, ECHO, AIDCO	Decide development aid policy and fund development aid projects, including in Mine Action	Support can include individual R&D projects, as well as test and evaluation activities. Usually more practical, field-oriented approach than previous category.
Defence oriented	National Defence ministries and Defence Procurement Agencies	Decide defence policy, fund defence related R&D activities and equipment procurement strategies	Support of national / international demining R&D programmes. Can collaborate with civilian entities on selected HD topics.
R&D organisations Academic, research centres	Universities, Research centres (whole range from public to fully private) EC: DG JRC	Execute mostly advanced research work and some development activities. Educational activities. Can investigate more speculative ideas. Provision of specific expertise (e.g. JRC).	Have participated extensively to HD related R&D projects. Can exploit synergies with other research domains. Can execute mandates but in general do not have a commercial agenda. Might lose end user requirement focus.
Defence	National research organisations	Execute advanced R&D projects linked to national defence requirements, including military demining.	Have participated to HD related R&D projects, when there was sufficient overlap with own activities and/or they received a clear mandate to deal with HD issues.
Large industry	See participants in EC co-funded projects	Execute advanced as well as very product / application oriented projects, as well as marketing and productionisation activities. Look at satisfying national / international market needs.	Have in some cases participated to HD related R&D projects, when there was sufficient overlap with own activities and interests. Can have important financial means. Interest in dual use opportunities.
SMEs	See participants in EC co-funded projects	Execute specific parts of R&D projects. Try to reuse own expertise. Look often for niche markets / applications.	Have in some cases participated to HD related R&D projects, when there was sufficient overlap with own activities and (usually) available resources. Can often take only limited risks, but are in turn quite flexible.
End users Individual organisations (NGOs, commercial, ...)	EC co-funded projects: Demira, MAG, MgM, NPA, BACTEC, etc.	Execute mine clearance projects, other Mine Action activities, and some R&D activities targeted at their specific needs.	Have participated in R&D projects mostly as end users, providing system requirements, field and test & evaluation expertise.
Supranational	GICHD, UNMAS	Policy making, coordination, resource mobilisation, standardization.	Support to individual R&D studies of general interest to the end user community. Interface to R&D community.

Table 2-1 Analysis of the key players' main activities and role (in the HD R&D context)

The EUDEM2 Data Base has been restructured and updated according to this subdivision and transferred into the DELVE Data Base, as detailed in Annex B. The complete list of organizations is reported in Annex C.

We will now briefly comment on the influences on these groups and interactions between them, and on the influence of external factors (politics), before looking at selected key players at the European Commission and end user level. An analysis of the relationship between HD and military demining R&D, including NATO's role, will close this chapter. The key players for the case study countries are further defined in Section 3. Another important actor, ITEP, will be detailed in D4.2 within the context of the analysis of test and evaluation activities.

2.1.1 Influences on Key Players and Interactions between them

The influences on, and interactions between, the main groups defined in Figure 2-1 can be illustrated by means of the following representative examples:

- **Donors/Decision makers, internally:** as can be clearly deduced from the European timeline (see Section 3.5), a number of R&D projects have been launched over the years following a clear political drive (e.g. the European Parliament resolutions). A similar situation applies to (i) Germany (see Section 3.1), on a somewhat smaller scale, and resulted in the Humin/MD project, and Belgium (see Section 3.4) for the HUDEM project.
- **Donors/Decision makers-R&D organisations:** although not in its core business, the UK Department for International Development (DFID) launched a call for Mine Action related proposals, which eventually allowed ERA Technology Ltd to carry forward the development of its hand-held GPR sensor. In this case the donor had a clear possibility of influencing the work of the R&D organization. This is usually much less the case for an institutional donor such as a research foundation supporting an academic institution, thereby often leading to an indirect, or loose, **R&D organisation-End users** interaction.
- **R&D organisations-End users, direct, HD:** a number of end users have been involved in demining related projects (e.g. European ones, or the TNO project described in the case study section), often because it was required by the underlying Donors/Decision makers. In this case the end users have the concrete possibility of influencing the work of the R&D organization.

Another example is the Humanitarian Demining Technologies Program Office in the Countermine Division of the US Army Night Vision Electronic Sensor Directorate (NVESD), which sponsored more than 120 demining R&D projects since the programme began in 1995. The US DoD established the HD R&D Program in response to the Presidential Decision Directive (PDD)-48¹, to "develop, demonstrate, and validate equipment for immediate use in various international HD missions." The US HD R&D Program focuses on "the development of new technology utilizing commercial-off-the-shelf equipment; the integration of mature technologies; and the leveraging of existing technologies from current Countermine Technology Programs used for military purposes."

- **R&D organisations-End users, direct, military:** in the case of military R&D the donor is often also representing the end user. He has therefore a sort of "double handle" on the R&D organizations, resulting in quite a strong influence.
- **R&D organisations-End users, indirect:** examples are interactions mediated by a third party such as GICHD, or a support action such as EUDEM2. This often results in a loose interaction.

2.1.2 External Factors (Politics)

Other external factors, in particular politics, do also influence the behaviour of the aforementioned groups. Some examples are reported below. Their effect can often be clearly seen from the timelines as well (Figure 3-9 and Figure 3-10).

¹ <http://www.humanitariandemining.org/process/humrdprogram.asp>

Underlying motivations of stakeholders:

There are many stakeholders in Humanitarian Demining, with quite different motivations. Understanding their underlying motivation can help in expectation management. Examples:

- Research on demining technology at universities is often sponsored by a national Ministry of Education or Technology. Although such a ministry may occasionally support Humanitarian Demining related R&D, its primary goal is the quality of education and/or scientific excellence and innovation. Research on demining technology is a way of training new engineers.
- Actual demining operations are often sponsored by a Ministry of Foreign Affairs or Development Aid, whose primary goal is the support of the (re-)development of a country or an area thereof. Demining is then only part of a set of support measures to achieve this.

External factors:

Public interest changes quickly, causing for example the shift of campaigns from one region to another. Demining organisations might have to follow and adapt their policy simply because they depend on the demands of their donors, and this can lead to inefficient usage of funds [EUDEM1999].

International interest as a whole for a topic like Humanitarian Demining can disappear in a short time period, as also illustrated in the timelines. A good technical solution which arrives outside the time window of interest is less likely to find a sponsor ready to fund its further development into a product of real interest for the end user.

Changing priorities:

The demining community realised that the original goals of the Ottawa treaty to “get the job done” within 10 years are very ambitious. In the action plan accepted at the 2004 Nairobi Summit on a Mine-Free World it is stated that “Successfully meeting the first mine-clearance deadlines in 2009 will be the most significant challenge to be addressed in the coming five years and will require intensive efforts by mine-affected States Parties and those in a position to assist them. The speed and manner with which it is pursued will have crucial implications for human security - the safety and well-being of affected individuals and communities”. [NAI2004, p.4, emphasis removed]

The aforementioned action plans ask for prioritisation of high impact areas²:

- “Urgently develop and implement national plans, using a process that involves, where relevant, local actors and mine-affected communities, emphasizing the clearance of **high and medium impact** areas as a matter of priority, and ensuring that task selection, **prioritisation** and planning of mine clearance where relevant are undertaken in mine-affected communities.”[NAI2004, Action#19]
- “Significantly reduce risks to populations and hence reduce the number of new mine victims, hence leading us closer to the aim of zero new victims, including by **prioritising** clearance of areas with **highest human impact**, providing mine risk education and by increasing efforts to perimeter-mark, monitor and protect mined areas awaiting clearance in order to ensure the effective exclusion by civilians [...]” [NAI2004, Action#20]

The demining efforts and therefore the corresponding technology development have to shift focus accordingly.

² Added emphasis is ours.

2.2 Donors/Decision Makers at the European Commission Level

Figure 2-2 provides an overview of the competences and roles of the European Commission's DG and Offices which participate and/or did participate in Humanitarian Aid, Mine Action³, and RTD.

A NUMBER OF DIRECTORATES GENERAL AND OFFICES OF THE EUROPEAN COMMISSION PARTICIPATE IN MINE ACTION:

Directorate-General for External Relations (DG RELEX)	Overall responsibility for EC Mine Action policy
EuropeAid Co-operation Office (also known as AIDCO)	Management of Mine Action projects, including funding of some research and development actions Collaboration with DG RELEX for the definition of priorities of Mine Action
European Community Humanitarian Aid Office (ECHO)	Management of emergency humanitarian Mine Action
Directorate-General Joint Research Centre (DG JRC)	Participation in Mine Action research projects, especially test and evaluation of equipment, and development of standards Represents the EC on demining international technical organisations
Directorate-General for the Information Society (DG INFSO)	Responsible for Mine Action technology research in the 4th, 5th and 6th Framework Programmes for RTD
Directorate-General for Research (DG RTD)	Participation in some Mine Action research
Directorate-General for Development (DG DEV)	Participation in some Mine Action research

Figure 2-2 DGs & Offices of the EC dealing with HD Activities (Source: [EC2003])

A more comprehensive description is reported in Table 2-2 below. Additional details are reported at:

- o http://ec.europa.eu/europeaid/projects/mines/whodoeswhat_en.htm
- o http://ec.europa.eu/comm/external_relations/mine/intro/index.htm (see in particular the "2005-2007 EU Mine Action Strategy").

European Commission Services involved in Mine Action	Description of Activity	Key Contact
DG External Relations	Handles relations with those countries which are not members of the European Union or the enlargement process and with all other countries that are not dealt with by DG Development. Coordinates the European Union's Common Foreign and Security Policy and administers more than 120 Delegations of the European Commission around the world. DG External Relations is responsible for policy formulation, coordinates the EU effort on Mine Action and chairs the Mine Action Coordination Group. It also manages the "Rapid Reaction Mechanism (RRM)" and can fund Mine Action projects with a maximum length of 6 months.	Daniela Dicorradò-Andreoni (daniela.dicorradò-andreoni@ec.europa.eu) See also: http://ec.europa.eu/comm/external_relations/search/policies.htm
European Commission Delegations	The Delegations of the External Service serve European Union interests throughout the world. There are 118 Delegations in third countries and 5 Delegations (in Geneva, New York, Paris, Rome and Vienna) at centres of international organisations (OECD, OSCE, UN and WTO). Delegations play a key role in the implementation of external assistance. This role has expanded greatly as a consequence of the Commission's 2000 deconcentration policy which provides EU external assistance more rapidly and more efficiently. Delegations	Please consult individual Delegation web-sites See: http://ec.europa.eu/comm/external_relations/delegations/intro/web.htm

³ http://europa.eu.int/comm/europeaid/projects/mines/whodoeswhat_en.htm#dev

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	are closely involved in programming, and they also manage projects in close contact with the EuropeAid Co-Operation Office and host country authorities. The assistance covers a range of areas from humanitarian assistance, support for democracy and human rights as well as independent media, over mine clearance and reconstruction, institution and capacity building, to traditional development aid.	
DG Development	Deals with development cooperation (policy formulation and programming of among others Mine Action) with the ACP countries (Africa, the Caribbean and the Pacific) and with the Overseas Countries and Territories. In addition, DG Development directly manages and coordinates EU relations with the 78 African, Caribbean and Pacific states and the 20 Overseas Countries and Territories. This group includes many of the poorest countries in the world. The objectives of development cooperation are: to foster the sustainable economic and social development of the developing countries; to promote their smooth and gradual integration into the world economy; to campaign against poverty and to develop and consolidate democracy, the rule of law and respect for Human Rights.	Gino Debo (gino.debo@ec.europa.eu) See also: http://ec.europa.eu/development/index_en.cfm
EuropeAid Co-operation Office	Mission is to implement the external aid instruments of the European Commission which are funded by the European Community budget and the European Development Fund. The Office is responsible for all phases of the project cycle (identification and appraisal of projects and programmes, preparation of financing decisions, implementation and monitoring, evaluation of projects and programmes) which ensures the achievement of the objectives of the programmes established by the Directorates-General for External Relations and Development and approved by the Commission. The thematic unit AIDCO/04 manages the budget line 19 02 04 (around €18 million yearly) that was created specifically to support projects in the area of the fight against antipersonnel landmines. This budget line is the main source of funding of the European Commission for Mine Action projects. Projects are managed by Unit E5.	Mr M Marie – Project Officer Unit E5 Ingeborg Thijn (ingeborg.thijn@ec.europa.eu) - Programme Manager Unit 04 See also: http://ec.europa.eu/europeaid/projects/mines/index_en.htm
European Community Humanitarian Office (ECHO)	The European Community is one of the main donors of humanitarian aid in the world. The European Community Humanitarian Office provides help to people in third countries who have been victims of natural disasters (earthquakes, floods, droughts, hurricanes) or man-made disasters (wars, conflicts, outbreaks of fighting). Since 1996, ECHO has spent €12 million on demining actions in Afghanistan, Angola, Cambodia, Eritrea, Iraq, Laos, Nicaragua, Russian Federation, Sri Lanka and Yugoslavia as part of its work in administering European Community aid programmes.	See: http://ec.europa.eu/echo/index_en.htm
Joint Research Centre (JRC – ISPRA)	The JRC's Humanitarian Security Unit (HSU) was in charge of the project "Test and Evaluation of Technologies in support to Humanitarian Demining". The HSU undertook actions related to the test and evaluation of demining equipment (off-the-shelf and prototype), and the establishment of associated T&E standards in support of the Centre's role of providing independent advice to the other Directorates of the European Commission and to the wider Humanitarian Demining community.	Adam Lewis (adam.lewis@jrc.int) See also: http://ipsc.jrc.ec.europa.eu/activities.php?id=1
DG Research	The Research Directorate-General can participate in Mine Action projects when they aim at furthering the knowledge of scientific processes involved in mine issues, such as the destruction of certain types of mines. A trial project aiming at the destruction of PFM-1 mine stockpiles in Ukraine is currently managed by the Directorate in collaboration with EuropeAid Cooperation Office.	Barbara Rhode (barbara.rhode@ec.europa.eu) See also: http://ec.europa.eu/research/fp7/index_en.cfm?pg=security http://ec.europa.eu/research/environment/themes/article_1353_en.htm

DG Information Society and Media	<p>Is responsible for the administration and management of a number of co-funded contracts for research and technological development (RTD) of demining technologies as well as support activities aimed at increasing the efficiency and coordination of RTD in this area.</p> <p>It is also responsible for administering the EC's research programme in the Sixth Framework Programme, which included work to improve demining technology within the context of "Improving Risk Management" (section 2.3.2.9).</p>	<p>Karen Fabbri (karen.fabbri@ec.europa.eu) See also: http://ec.europa.eu/information_society/qualif/env/index_en.htm</p>
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Table 2-2 Main EC services dealing with Mine Action (Source: EC websites)

2.3 End Users

The main characteristics of the end user group have been briefly summarised in Table 2-1. From the organisational point of view the end user community is quite diverse and its structure varies significantly from region to region in terms of prevalence of NGOs, commercial or military organisations, as well as in terms of presence or absence of national Mine Action Centres (see also Figure 2-1). The interested reader is referred to the International Campaign to Ban Landmines (ICBL)⁴ and the Geneva International Centre for Humanitarian Demining (GICHD)⁵ publications, amongst others.

At supranational level, from the United Nations point of view coordination and resource mobilization remain central responsibilities of the United Nations Mine Action Service, UNMAS⁶ (created in 1995 to serve as the UN focal point for Mine Action and to support the UN's vision). The Inter-Agency Coordination Group on Mine Action (IACG) brings together all UN entities involved in Mine Action to coordinate the activities of the various UN partners and monitor progress against the five-year UN strategy. In addition, the Steering Committee on Mine Action (SCMA), which includes the ICBL, the ICRC, the GICHD (see below) and a number of operational NGOs in addition to the IACG members, is a mechanism where country issues and mine-related policy issues are discussed between UN members and other partners.

One of the major players in Mine Action is the Geneva International Centre for Humanitarian Demining (GICHD). The GICHD (<http://www.gichd.org/about-gichd/statutes/>) has been created to promote international co-operation in the field of Mine Action by training practitioners, by developing methods and by providing the required information to the different actors.

In this context, the Centre undertakes the following activities:

- Establish and maintain a group of internationally recognised experts in charge of analysing the field experience made in different contexts, to identify current problems, and to propose solutions in form of standards or methodologies and methods.
- Create and maintain an information management system (IMSMA) adapted to the needs of the United Nations and existing Mine Action Centres (MACs).
- Organise periodic conferences allowing the persons in charge of Mine Action operations to exchange their experiences.
- Organise training courses for potential managers of Mine Action operations as well as for information management specialists.
- Publish technical catalogues of demining equipment.

⁴ <http://www.icbl.org/>

⁵ <http://www.gichd.org/>

⁶ <http://www.mineaction.org/>

2.4 HD vs. Military R&D Relationship

Due to the nature of the landmine problem, military approaches and R&D activities can obviously not be ignored even if the target scenario is strictly humanitarian. This is also reflected in Table 2-1. We will therefore briefly look in the following at the relationship between the two types of R&D activities, as well as the role of one the key players in this area, NATO.

Background

Military countermine equipment has been focused on large scale combat operations for a long time. When breaching operations of minefields are part of a combat operation, the risks and time pressure are assessed differently from the way they are assessed in Humanitarian Demining. Equipment and tools for these operations are designed according to these needs. Many defence research laboratories have been involved in the development of tools and equipment for these needs since a long time. Conflicts like the Falkland War (1982) and the Kuwait-Gulf war (1991) are examples where minefields had an influence on the operations. This triggered corresponding research activities.

Post-war mine clearance has been of interest for the military as well. Most of the mines from the Second World War (1939-1945) have been removed by military personnel. After the end of the Cold War armed forces became more and more involved in peace-keeping missions or even humanitarian aid missions. These types of missions are characterised by the use of lower levels of force or even no use of force at all.

In these cases the mines remaining in the area of operation affect the freedom of movement and may therefore influence the effectiveness of the military mission. This has led to a need for countermine equipment for peace keeping missions. The acceptance of risks and time pressure is in this case different from the combat operation condition, and the situation resembles more the situation for Humanitarian Demining. Still there are differences. The military will clear mines primarily to ensure their own freedom of movement. The budgets and logistic support in the context of military operations are different as well. The civilian population will benefit from these military operations. However, priorities and clearance levels (quality) may differ from the rules for Humanitarian Demining.

In addition, as a part of the activities to win "the hearts and minds" of the local population some countries provide military support to Humanitarian Demining. This can range from providing training programmes for local deminers to performing the actual demining operations. Only in the latter cases the military will work according to Humanitarian Demining standards.

NATO activities

Requirements and developments for military countermine operations from the military operational point of view are topics which are discussed in a NATO working group on engineer corps issues. This so called "Landgroup 9" reports to the NAAG (NATO Army Armaments Group), which in turn reports to the CNAD (Conference of National Armaments Directors).

Although some technical and operational requirements have been formally agreed by the member nations of this group, no joint technology development has been initiated. Some bi-lateral developments have taken place, but these are based on national funding sources.

This group has also initiated a NATO standardisation agreement (STANAG) on test procedures.

Countermine technology from the scientific research and development point of view is discussed in a task group under the SCI (Systems Concepts and Integration) panel, which reports to the RTB (Research and Technology Board). The task group consists of researchers from defence research laboratories in the field of countermine equipment. The group is a forum for discussion and assessment of technological developments. Workshops on special topics have been recently organised for example on remote neutralisation and on remote detection. In general the techniques discussed here are also published in the open literature. However the discussions are on a government to government base and can therefore be at a classified level which allows the exchange of more detailed information.

Some additional activities are sponsored by the Science for Peace programme, which involves also non-NATO countries. An example is a workshop series on explosives detection hosted in Russia.

Developments of military equipment

As an example of the development of military countermine equipment we discuss some national developments of technology for route clearance. All examples aim at a platform with a multi-sensor system mainly targeted at the detection of anti-tank mines.

- In the late '90s the US spent a considerable effort in the development of multi-sensor detection platforms. Contracts to build several systems for evaluation were placed. Certain elements of the technology developed are now in service in Iraq and Afghanistan. No immediate further developments are foreseen and the research focus has shifted.
- In the same timeframe Canada developed the ILDP (Improved Landmine Detection Platform) for route clearance. Four units were built and the system is now in service in Afghanistan. No immediate further developments are foreseen.
- Around 2000 the UK awarded two contracts to industry for the first (study) phase of the MINDER programme for vehicle mounted mine detection. Phase two for the actual development never started.
- France and Germany joined their national efforts in the MMSR-SYDERA programme. The demonstrator system has been delivered to the national governments early 2007. Government evaluation of the system is foreseen in 2007 (for details see also the Germany country section).

This illustrates that, despite the fact that all nations have similar but not equal requirements, little co-operation has taken place (except in the case of the MMSR-SYDERA programme).

Effects on development of demining technology

Spin-in to Humanitarian Demining

Based on the work performed for military countermine equipment, in the mid-'90s there was widespread optimism that a breakthrough could be achieved in demining technology. For example, the general opinion was that the detection performance could be significantly improved by combining different detection techniques, while at the same time reducing the false alarm rate. Several nations started large research programmes to develop this type of technology.

Around the year 2000 it became clear that these techniques, which might show success for the detection of large anti-tank mines, were less suitable for anti-personnel mines. This disappointment was in part due to fundamental physical limitations which blocked technological progress. May be even more important was the misperception of the main problems in demining operations, due to the lack of communication with the end users. For example, taking the military user as a starting point, one assumes well trained users, good logistics support, significant budgets, etc. These conditions are clearly different in Humanitarian Demining.

The research into landmine detection techniques did not completely stop at that point. More incremental improvements were instead pursued. The perception of the actual end users needs did also improve. This resulted for example in the development of hand-held mine detectors which combine metal detection and ground penetrating radar. In this case the perspective of military use (and sales) of these systems justified the funding.

Development for Humanitarian Demining only would not provide a solid business case, because the expected market is too small for an acceptable return on investment. This was well illustrated by a case study by Newnham and Daniels [NEW2001], where the authors argued that the cost of a relatively simple improvement of a metal detector could not be covered by the total market for Humanitarian Demining, because the sales numbers are so small that this would lead to unacceptable price increases.

Spin-off to military countermine

In the situation where the military use countermine equipment in peace keeping operations, they often benefit from Humanitarian Demining expertise. Indeed, organisations active in Humanitarian Demining have often already tested and used certain types of equipment of interest for military use. For example, the results of tests of small flail systems were of interest for the procurement of such units by the Netherlands Ministry of Defence. Operational procedures developed by Humanitarian Demining organisations are of interest as well for military use in peace keeping missions.

3 COUNTRY LEVEL AND EUROPEAN EVOLUTION - CURRENT SITUATION

The following sections provide an overview of the key events in Mine Action in the form of a timeline, and an overview of the previously identified key players and their main interactions in the form of the original EUDEM2 2004 organigrammes and their textual updates, with emphasis on R&D related work (and partially on military activities as well). The bulk of the HD related R&D activities did usually take place before 2004 (exceptions are the German Humin/MD project and the Japanese activities). Redrafting the organigrammes in detail would therefore have provided little added value.

Four European countries (Belgium, Germany, The Netherlands and the United Kingdom) were selected together with Japan; detailed descriptions of the most important national activities are provided where appropriate. The situation at the European level was also analysed, with emphasis on RTD activities sponsored by the European Commission.

The study team started from the existing body of literature and contacts accumulated from its extensive participation to European and national R&D programmes in the past decade, complemented where necessary with targeted literature surveys (see also the Bibliography section). A number of direct contacts and where appropriate interviews were used for the selected countries, both to compile the detailed descriptions of the most important national activities, and to complement our analysis. Representative events, organisations and projects were selected rather than seeking to be exhaustive.

What emerges from the following overviews is that:

- Humanitarian Demining activities started in earnest during the late '80s-early '90s and soon made the headlines thereafter. As one of the consequences important RTD efforts were started, including a strong EC R&D civilian programme.
- Different countries replied in very different ways (research fragmentation at the European and national level - fragmentation aspects are discussed in D4.2).
- As with many other "new" topics all involved actors had to climb their share of the learning curve, new structures and ways of collaborating had to be invented (e.g. the International Test and Evaluation Programme, ITEP), with mixed success.
- Despite the considerable amount of R&D funding just a few results are currently being fielded (these aspects are analysed in detail in D4.2).
- Examples of coordinated *end-to-end planning* by creating coherence between (1) policy, based on political decision, (2) RTD, testing and production of equipment, and (3) timely deployment, supported by a well organised and co-ordinated organisational structure, showed effectiveness in bridging the gap between R&D and Deployment.
- From the review of the EC R&D projects it appears that, at the current funding/project size, the typical timeframe of 2-3 years is very short for R&D projects, which include a requirements phase, a specification phase, development and integration, demonstrator building, laboratory testing and initial field tests by end users, to be effective. Currently the timeframe for R&D is not sufficiently synchronised with the timeframe of Humanitarian Action funding/operation.
- At the R&D level the subject started to lose importance as from around 2004, being mostly taken over by security related issues and environmental risk management as a whole. The current reduction of the EU Humanitarian Demining research programme and its incorporation into the wider "Improving Risk Management" strategic objective, which was foreseen as a way of generating synergies with other types of responses to humanitarian crises management, where technologies such as Information Management, Geographical Information Management and Earth Observation are more likely to be used in a 'System Approach', did not generate the expected synergies.
- Military R&D efforts are still ongoing, although refocused around specific topics (e.g. MMSR-SYDERA in Germany), and likely to continue for the foreseeable future.

- On the civilian front some individual, mostly academic efforts are still ongoing at national level (e.g. KCL NQR work in the UK), whereas large concerted projects are ending – like for European projects – and might not be continued (Humin/MD in Germany, MEXT in Japan, HUDEM/BEMAT in Belgium).
- The evolution of the national and international Mine Action funding levels, partly including the R&D effort as well, is available in the Landmine Monitor report, in particular [ICBL2006, pp. 64-72] which contains a detailed description. What emerges is that Mine Action funding is mostly levelling off, including at EC level, but not decreasing and still substantial.

Lastly, this section serves as a basis for the detailed lessons learned analysis of D4.2.

3.1 Germany - Overview

3.1.1 Overall Evolution (Timeline)

Figure 3-1 and Table 3-1 illustrate the main actors, projects and the evolution of Humanitarian Demining RTD activities, and partly of military activities as well, in Germany.

AAMIS	Airborne Minefield (MF) Detection System
AMOS-M	MD-UXO Detector, vehicle based array (Rheinmetall LS)
BAM	Federal Institute for Materials Research and Testing
BMBF	Federal Ministry of Education and Research
BWB	Federal Office for Defence Technology and Procurement
CIMIC	Multi-sensor equipment for landmine detection in civil mine clearance operations (European project)
CUTEC	Clausthaler Environment Technology Institute
DFG	German Research Foundation
DLR	German Aerospace Centre
DNQR	Double Nuclear Quadrupole Resonance
EC	European Commission
EDT	Explosives Detection Technique
EM	Electromagnetic
FEZ	Research and Development Centre
FFO	Federal Foreign Office
FGAN	Research Establishment for Applied Sciences
FhG	Fraunhofer Society (for Research)
FHR	Research Institute for High-Frequency Physics and Radar Techniques (FGAN)
FMCL	Federal Ministry of Commerce and Labour (BMWA)
FMER	Federal Ministry of Education and Research (BMBF)
FMOD, MoD	Federal Ministry of Defence (BMVg)
FOM	Research Institute for Optonics and Pattern Recognition (FGAN)
FZJ	Research Centre Juelich
GGA	Institute for Geo-scientific Common Tasks
GICHD	Geneva International Centre for Humanitarian Demining
GPR	Ground Penetrating RADAR
Humint/MD	Humanitarian Demining (R&D programme of FMER)
ICT	Institute for Chemical Technology (FhG)
IPA	Institute for Manufacturing Engineering and Automation (FhG)
IPK	Institute for Production Systems and Design Technology (FhG)
IR	Infra Red
IRFTRS	Institute of Radio Frequency Technology and Radar Systems (DLR)
IZFP⁷	Institute for Non-destructive Testing (FhG)

⁷ Labelled as "FhG-IZFP" in the organigramme.

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ITEP	International Test and Evaluation Programme
JRC	Joint Research Centre of the European Commission
KAMINA	EDT system (electronic nose)
MAGNETO	Computer Aided UXO Survey System
MAG-SENSOR	Sophisticated Magnetic Field Sensor
MD	Metal Detector
MDD	Mine Detection Dog
Mech	Mechanical
MMSR	Mobile Mine Search and Clearance System
MOU	Memorandum of Understanding
MSMS	Multi-Sensor Mine Signature
MWR	MicroWave Radiometer
NBS	Neutron Back-Scatter
NQR	Nuclear Quadrupole Resonance
PT	Project Funding Sub-Agency (of FMER)
T&E	Test and Evaluation
UWB	Ultra-Wide Band
UXO	Unexploded Ordnance
WIWEB	Bundeswehr Research Institute for Materials, Explosives, Fuels and Lubricants (BWB)
WS-STUDY	Workshop and Study
WTD	Defence Techniques Proving Ground (BWB)
X-Ray BS	X-Ray Back-Scatter

Table 3-1 Germany Glossary

In the following timeline (Figure 3-1) the top half contains in particular important political events, decisions and conferences. The bottom half contains indications on R&D projects, in particular defence related ones (top), MMSR and MMSR-SYDERA (centre), Humin/MD (BMBF), and data collection and field trials (bottom). (Work on the AMOS MD array is mentioned as well, due to its relationship with the MMSR project.)

An overall analysis of the German demining R&D situation is reported in D4.2. Here we wish to briefly mention the following salient facts:

- Mine Action programmes were supported early on (as from 1992), together with early R&D activities such as the JRC study (1994-1995) and the involvement in the European CIMIC project (1997). The ITEP MoU was on the other hand signed after the other countries (2002).
- The two largest R&D activities are the Humin/MD project on the civilian side and the MMSR-SYDERA (formerly MMSR) project on the military side. These are described in more detail below.
- It is worthwhile to mention the work of BAM in the area of test and evaluation of existing tools and systems.

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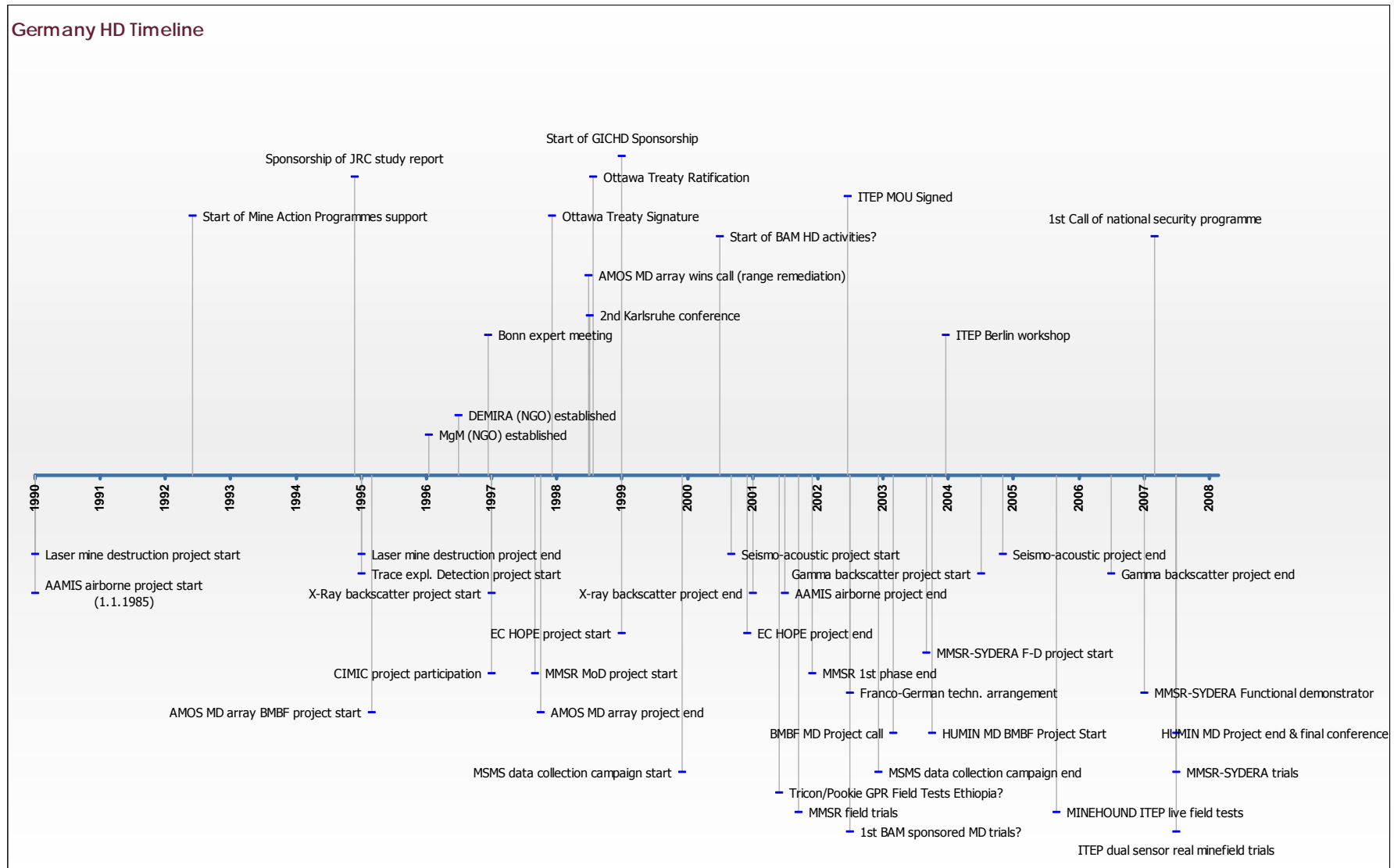
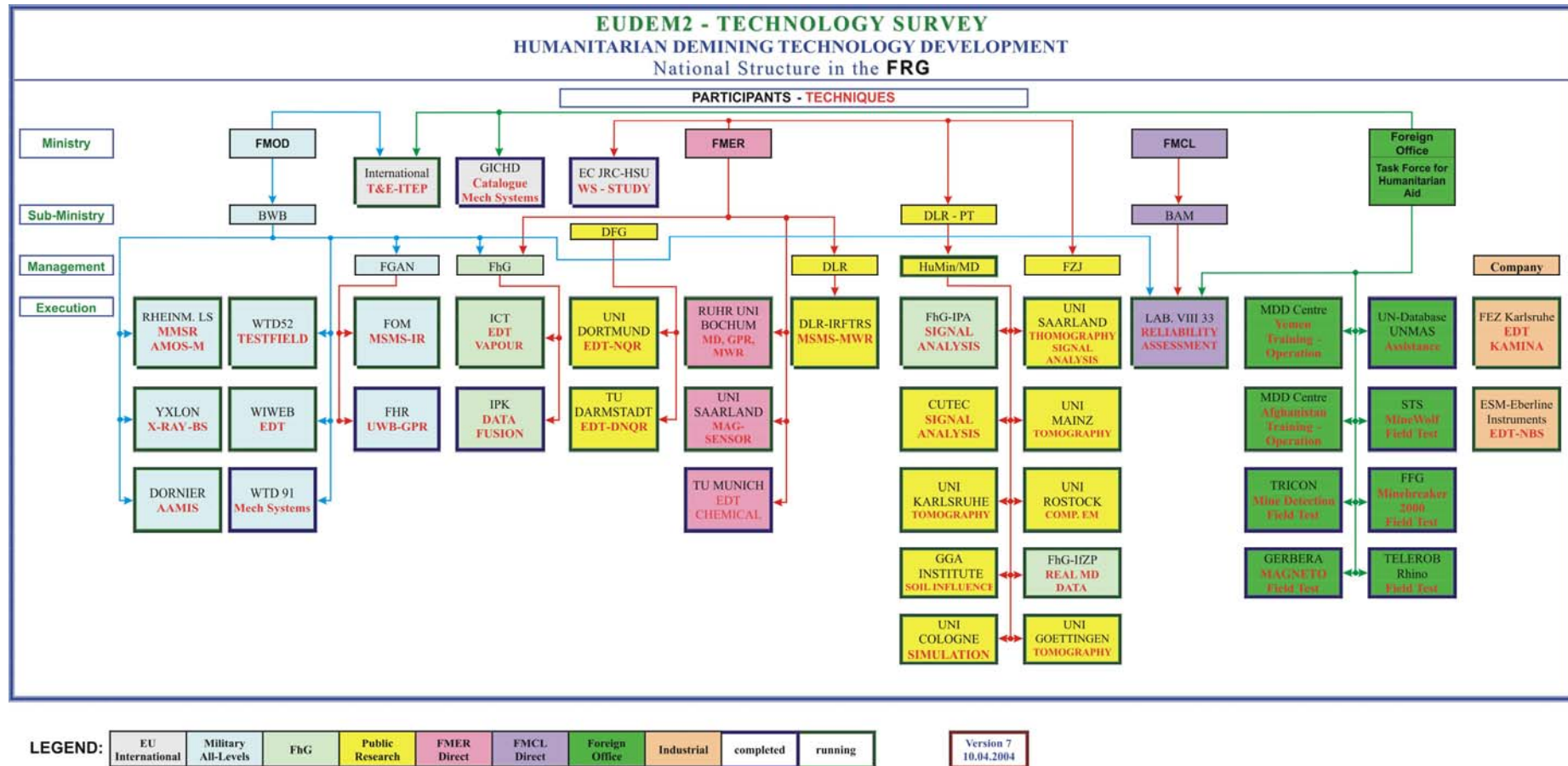


Figure 3-1 Germany RTD Activities Timeline

3.1.2 2004 Organigramme

The financial/coordination aspects, as well as the relationship between the different projects, until 2004, are illustrated in Figure 3-2. The used abbreviations are provided in Table 3-1.



REMARK: This overview is showing the past and running programmes of the FRG from 1994 up to now. The structures are reflecting the constitutional federalism of the FRG.

Figure 3-2 Overview of the German National Projects – Situation until 2004

3.1.3 Current Situation

The following main updates and changes have taken place with respect to the organigramme⁸ shown in Figure 3-2:

- Artificial nose project (demining related), ICT (Fraunhofer Institute for Chemical Technology⁹, Pfinztal), MoD supported:
Completed in 2003, although activities in the explosive detection field continue.
- Change detection for the detection of minefields and IEDs, UAV based (evaluation study), MoD supported:
Scheduled for 2007-2008.
- Gamma-backscatter confirmation project (confirmation of AP, AT mines), GSI (Society for Heavy Ions Research, Darmstadt¹⁰), MoD supported:
Completed 2004-2006, test activities ongoing.
- LIBS (Laser Induced Breakdown Spectroscopy) trace explosive detection, for the identification of landmines using an upgraded conventional prodger, Technical University Clausthal (Clausthal-Zellerfeld), MoD supported:
Started 1999-2000, ongoing. Smart prodger field testing scheduled for 2007.
- NQR bulk detection of TNT, Darmstadt Technical University and Dortmund University, DfG supported:
Possibly completed.
- Seismo-acoustic detection project, Kayser-Threde GmbH, MoD supported:
Completed Sept. 2000-Nov. 2004 [BRU2006], activities continuing (outside MoD support).
- BAM dual sensors ITEP tests, FFO (main sponsor) and MoD supported:
Ongoing.
- BAM MD tests within ITEP, FFO supported:
Completed, 2005-2006.
- GICHD "Guidebook on Detection Technologies and Systems for Humanitarian Demining", FFO supported:
Completed, 2005-2006.
- ITEP Mini-Minewolf tests, MoD supported
Scheduled for 2007.

3.1.4 Main Current National Activities

The following sections describe the largest current R&D activities, namely the MMSR-SYDERA project on the military side and the Humin/MD project on the civilian side. They are complemented by a brief note on some relevant aspects of the German foreign policy towards Mine Action, which can likely be generalised to other countries.

MMSR-SYDERA

Description and Objectives: The MMSR-SYDERA Franco-German collaborative project [MMSRa] resulted from the combination of two national feasibility studies, the German MMSR (Mobile Mine Search and Clearance System) and the French SYDERA (Vehicle-Mounted Close-in Mine Detection System). Current consortium members are Rheinmetall Landsysteme GmbH, Germany, Thales Airborne Systems and MBDA, France. The system is targeted primarily at defence and peace-keeping applications.

⁸ Academic activities were not re-screened in detail. MoD support runs via BWB.

⁹ Fraunhofer Institut für Chemische Technologie.

¹⁰ Gesellschaft für Schwerionenforschung mbH (Helmholtz-Gemeinschaft).

Rather than a purely detection approach this remote-controlled “dual mode” (mine detection and clearance) system consists, in its latest configuration, of four vehicles – smart decoy, heavy decoy, detection & confirmation, command & control – to be combined according to the target scenarios: in some cases a fast advance is foreseen (e.g. fast route opening), relying mostly on the clearance component (consisting of smart and heavy decoy vehicle and the command & control vehicle) , whereas in others (e.g. sensitive route opening, or when mines have already been encountered), additionally the detection component is activated and it is recognized that the advance will be much slower. The detection component itself relies on the combination of metal detectors, GPR, multi-spectral opto-electronic and fast neutron based confirmation sensors.

The resulting system is complex and specialised and definitely targeted to military applications. A transposition to some Humanitarian Demining scenarios is not totally excluded, it would however still necessitate the use of specialised military personnel.

Milestones: MMSR-SYDERA’s development milestones are the following (see also the timeline plot):

September 1997	MMSR MoD project start
September 2001	MMSR field trials
End 2001	MMSR 1st phase end
2002	Franco-German techn. arrangement
September 2003	MMSR-SYDERA F-D project start
End 2006	MMSR-SYDERA Functional demonstrator
January-July 2007	MMSR-SYDERA trials
June 2007-End 2008	Interim phase
2009-2011	Full-scale development*
2012-2013	Trials*
2014	Production and service*

Steps marked with “*” are conditional on the outcome of the 2007 trials, the subsequent agreement on an operational system concept, and finally on the confirmation of the financial commitment (which in the case of Germany will be decided by Parliament, like for all other expenses exceeding 25 MEuro).

Financial envelope: The project development costs have been reported at around 20 MEuro [MMSRb]. It is expected that France and Germany will need of the order of 10 complete systems (vehicles plus infrastructure) each, whose cost can be estimated to be in the multi-million Euro range, plus personnel and infrastructure costs.

Project specificities: This project takes place within a well regulated and standardised military procurement cycle (Customer Product Management, or CPM, in Germany, roughly equivalent to the British Smart Procurement Initiative), which is financially entirely supported by the customer (except during interim phases between subsequent projects). It is worth noting that the customer could exercise a right to recover part of the development costs should the system be exported. Also, the industrial partner might have to reimburse part of the contract in case the foreseen performance specifications are not met.

Humin/MD

Description and Objectives: The German project network "Metal detectors for Humanitarian Demining (Development potentials for data analysis and measurement techniques)" is funded by the German Federal Ministry of Education and Research (BMBF). Humin/MD started in 2003, after an analysis of existing national and international R&D efforts which led to the decision of concentrating on the improvement of metal detectors, still the only sensors routinely used in the field. Its scientific/technical objective is to reduce the metal detectors' high false alarm rates by means of new mathematical methods that work with data measured from commercial off-the-shelf metal detectors [HUMIN]. Humin/MD brings together more than 10 German universities and research institutions with a total funding of 4.5 MEuro.

Structure: Humin/MD is structured around three main fields of research:

(1) Local 3D imaging (tomography), which is based on two approaches:

- Real-time inversion, which attempts to reconstruct the metal distribution in the soil from the measured signals. Broadly speaking two situations are possible:
 - The target's shape is known a priori.
 - The target's shape is unknown (no a priori assumptions), but one still attempts to reconstruct it, together with the target's main parameters.

This approach is mathematically more advanced and more demanding than the first one, leading to slower but more reliable algorithms.

First results with this approach are reported as being good at high operating frequencies, while they still have to be transposed to lower frequencies.

- Fast forward modelling, which calculates the signals resulting from a known metal distribution in the soil. These calculations are at the root of an iterative procedure which starts from an initial assumption on the target's distribution, compares the expected values with the measured ones, adapts the target's distribution according to the resulting difference, recalculates the expected values, and continues until a good match is found.

(2) Signal analysis, to improve target discrimination (including by modern pattern extraction and classification methods such as Support Vector Machines). Phenomenological or physical relations are considered when implementing these methods. In addition, strategies for pre-processing of the data have been developed (e.g. for noise reduction).

(3) Research on soil influence and on the optimisation of measuring techniques.

An interim report was released in September 2006 and is available from [HUMIN].

Project specificities:

- End users have been consulted at the beginning of the project, as well as regularly thereafter.
- Although formally not part of the project network, German equipment manufacturers have been consulted and have collaborated with it.
- The need to reach practical goals has been stressed all along the project.

Outlook:

- Final results will be detailed to the German equipment manufacturers individually, as well as during a final project conference in July 2007.
- All final results will be made available, and it is expected that they will sufficiently clear to tell what can be done with an MD and what not.
- Any commercial system developments will have to be funded by the interested commercial party, given that the sponsoring organisation (BMBF) is restricted by its statutes to support pre-competitive research, similarly to EC sponsored R&D activities (at a level which is actually even more biased towards basic research).

It is however expected that the obtained results will be sufficiently clear to allow a commercial organisation to decide whether to implement them in a product or not.

- Possible other application domains for the project network's partners: security.

Humanitarian Demining Policy

It is quite interesting to note that the German foreign policy towards Mine Action is characterised by the following aspects, which can be likely generalised to a number of countries that are currently supporting Mine Action:

- It is likely that support to Mine Action will be reduced in the medium term, also to privilege other humanitarian problems which are much larger in amplitude.
- The mine and UXO problem is seen as a national one (Article 5 of Mine Ban Treaty), with donors assisting in capacity building (amongst other priorities).

As a consequence, and considering that only incremental improvements are perceived as having been introduced in the field so far, it is unlikely that the German Federal Foreign Office will sponsor further T&E of new detectors and systems. However, any system showing positive results might still be supported if clearly deemed to be "field deployable".

Acknowledgements

Some of the previously discussed elements have been collected in discussions with Johannes Dirscherl (FFO), Axel Kaspari (Rheinmetall LS), Gerd-Henning Klein (PT-DLR) and Hartmut Eigenbrod (Fraunhofer Institute), and Klaus Neugebauer (BWB).

3.2 United Kingdom - Overview

3.2.1 Overall Evolution (Timeline)

Figure 3-3 and Table 3-2 illustrate the main actors, projects and the evolution of Humanitarian Demining RTD activities, and partly of military activities as well, in the UK.

BGS	British Geological Survey
CHA	Conflict and Humanitarian Affairs (DFID)
DCMC	Dismounted Countermine Capability
DEODS	Defence Explosive Ordnance Disposal School
DFID	Department for International Development
DOE	Department of Education
DPA	Defence Procurement Agency
DSTL	Defence Science and Technology Laboratory
DTU	Development Technology Unit (Warwick University)
EDT	Explosive Detection Technique
EPSRC	Engineering and Physical Sciences Research Council
FCO	Foreign & Commonwealth Office
GPR	Ground Penetrating RADAR
HDTDP	Humanitarian Demining Technology Development Programme
IR	Infra Red
ITEP	International Test and Evaluation Program for Humanitarian Demining
KCL	King's College London
MAG	Mines Advisory Group
MCMC	Mounted Countermine Capability
MD	Metal Detector
MINDER CAP	Vehicle Based Sensor Technology Programme
MITC	Mine Information Training Centre (MOD)
MOD	Ministry of Defence
MOU	Memorandum of Understanding
MSMS	Multi-Sensor Mine Signature
NBS	Neutron Back-Scatter
NQR	Nuclear Quadrupole Resonance
PHMD	Portable Humanitarian Mine Detector
REMIDS	Remote Minefield Detection System (DERA)
T&E	Test and Evaluation
TME	Thales Missile Electronics (UK)
UK - CMF	United Kingdom Treasury Capital Modernisation Fund (inter-ministerial)
UWB - SAR	Ultra-Wideband Synthetic Aperture RADAR
UXO	Unexploded Ordnance

Table 3-2 UK Glossary

In the following timeline (Figure 3-3) the top half contains in particular important political events, decisions and conferences, as well as key dates in the development of the commercial ERA GPR systems (relevant to the gap to market case study). The bottom half contains in the centre indications on R&D projects, in particular those which eventually led to the MINEHOUND system (again of relevance for the gap to market case study), the DFID procurement call of 1999, indications on some military projects (from the early Falkland Islands work to MCMC and DCMC), and data collection and field trials (bottom, mainly the PHMD and MINETECT/ MINEHOUND dual sensor systems).

An overall analysis of the UK demining R&D situation is reported in D4.2 (see also Section 5.1). Here we wish to briefly mention the following salient facts:

- UK NGOs were amongst the first to be established (1988-1989), and are currently amongst the largest (Halo Trust, MAG).
- Important European R&D conferences were held in Edinburgh in 1996 and 1998.
- It is worthwhile to mention the 1999 DFID procurement call (see also Section 3.2.4), the early establishment of the HDTDP programme at Warwick University (1994) and of the Cranfield Mine Action Unit in 1999, as well as the early military landmine detection work (1983-1986).

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UK HD Timeline

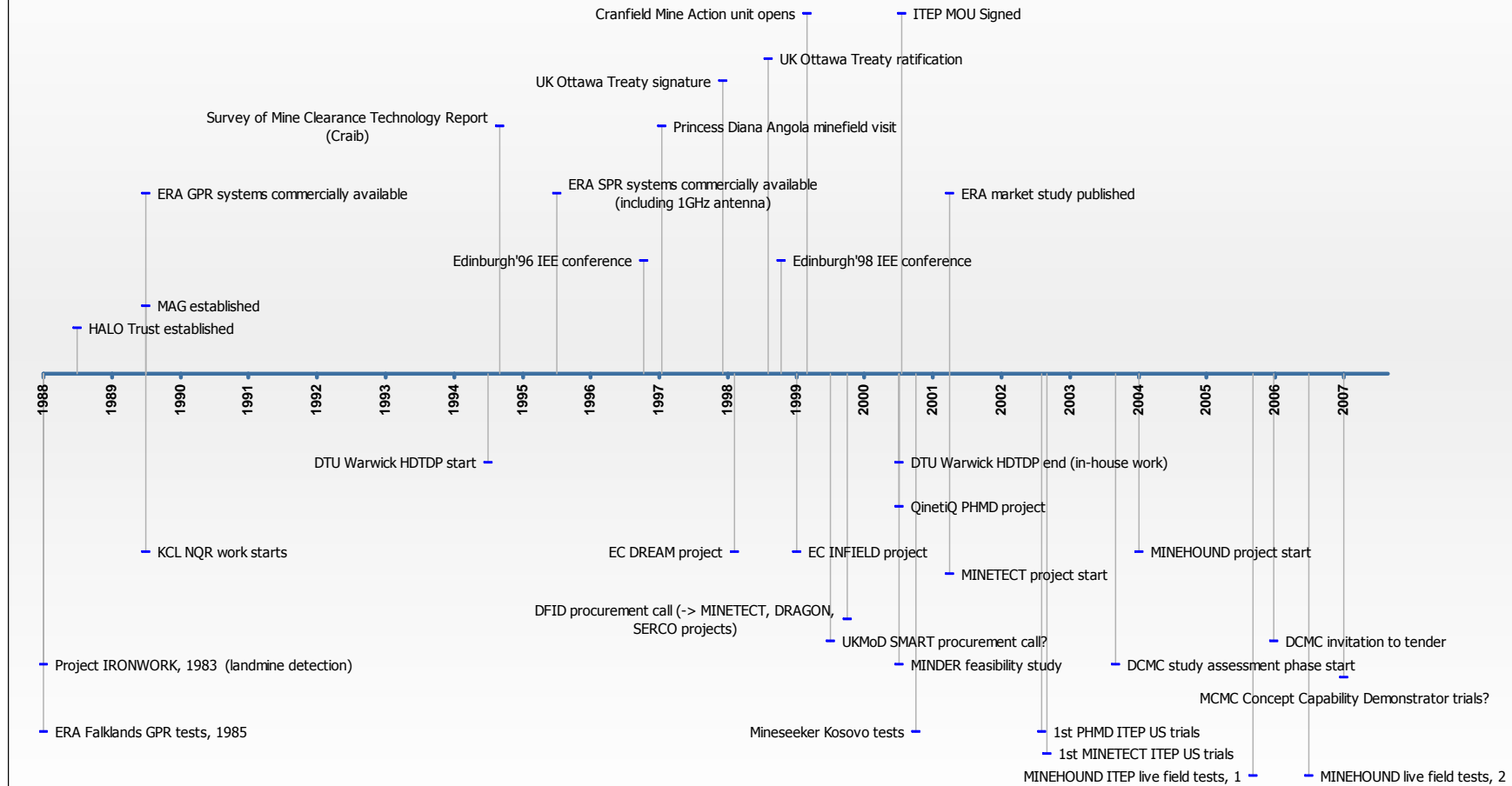


Figure 3-3 UK RTD Activities Timeline

3.2.2 2004 Organigramme

The financial/coordination aspects, as well as the relationship between the different projects, until 2004, are illustrated in Figure 3-4. The used abbreviations are provided in Table 3-2.

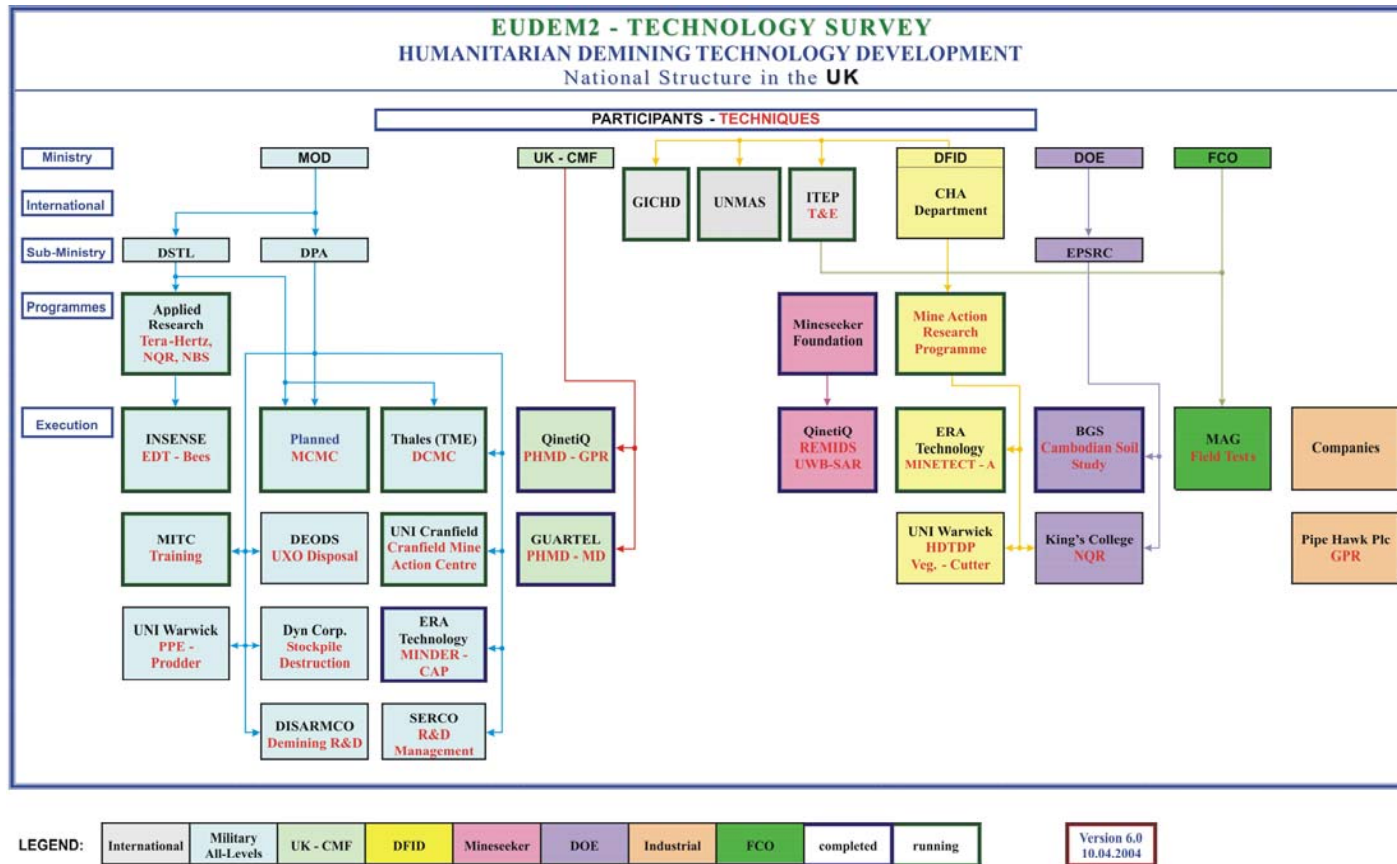


Figure 3-4 Overview of the UK National Projects – Situation until 2004

Notes on the previously shown organigramme (Figure 3-4):

- The department dealing with Mine Action within DFID is at present called CHASE (Conflict, Humanitarian and Security Department).
- ITEP support was purely DFID (no link to FCO).
- The Mineseeeker Project involved QinetiQ and the "Lightship Foundation".
- UK-CMF is a sub-ministry under the Ministry of Treasury.
- DSTL sponsored activities have not been rechecked in detail.

3.2.3 Current Situation

The following main updates and changes have taken place with respect to the organigramme shown in Figure 3-4:

- The Dismounted Countermine Capability programme (DCMC) was reported to be progressing as planned, an invitation to tender having been issued to four companies on 19 December 2005 [UK2006]. It is expected to deliver new metal detectors, training and personal protective equipment in 2008 and an explosive line charge, for rapid breaching, in 2011 [UK2005].
- The Mounted Countermine Capability programme (DCMC) seems to have had its funding removed. A Concept Capability Demonstrator was however reported as having received funding to undergo trials during 2006-7 [UK2005].
- KCL NQR detection related work is ongoing (see separate details).
- A number of MINETECT/MINEHOUND field trials have been supported, mostly under the ITEP banner. MINEHOUND is now in production and available from Vallon GmbH.
- Although Warwick's Development Technology Unit HDTDP in-house work ended, there is ongoing interest by the Cambodian Demining Workshop (CDW, Phnom Penh) in manufacturing Tempest vegetation mini-flails and PPE (Personal Protective Equipment).

3.2.4 Accompanying Notes

We will conclude the overview of the situation in the UK with a brief look at Humanitarian Demining related R&D supported by a Donor/Decision maker, the Department for International Development (DFID), followed by a brief look at the R&D activities on explosive detection of an academic institution, King's College London, which has been active on the subject for more than 15 years.

DFID sponsored activities

- DFID has funded in the past the development, testing and field trials of particular pieces of equipment, for example "The Tempest" vegetation clearance vehicle and the "Pearson Tractor" in Cambodia. It has also co-funded, as part of a European consortium, the development and field trials in Mozambique of an airborne multi-sensor detection system¹¹. Where possible, it has also encouraged the local production of equipment, such as the "Tempest" in Cambodia [DFID2000].
- DFID also launched a call for Mine Action related proposals, in late 1999, aimed at assisting carefully focused research and development projects targeted to making mine clearance more cost-effective. This action stimulated nearly forty responses under the themes of minefield survey, mine detection, clearance, operational safety and management systems. This initiative was Mine Action specific. Eventually three projects were retained, i.e. MINETECT (GPR-EMI hand-held dual sensor), DRAGON (pyrotechnic torch developed by DISARMCO) and SERCO (Risk Management in Mine Action).
- The DRAGON project was sponsored at approximately £500,000 over 2003-2004 [DFID2005] and at approximately £200,000 over 2005-2006 [ICBL2006]. ERA Technology Ltd (developer of the MINETECT) was funded with £867,615 over 2005-2006 [ICBL2006].

¹¹ Actually the Airborne Minefield Detection Pilot Project.

At this moment the technology innovation component of DFID is reported as no longer having any interest in HD.

NQR activities at KCL

- Work on the mine detection problem at KCL began already in 1989 but using cross-polarisation methods which involved a switched magnetic field. The work was successful but by 1991 KCL realised that pure NQR signals in RDX could be seen by normal pulsed methods with sufficient sensitivity, without the need to apply a magnetic field [SMI2007].
- KCL is still working on the problem, but now using noise excitation methods (work which began in 2002) and more recently (2004) the use of parametric maximum likelihood data processing.
- *KCL expects to have a demonstrator ready in 2007, funding permitting.*
- KCL also started to apply in 2006 MEMS techniques to detect NQR signals from landmines (collaborative project with CAPE at the University of Cambridge).

Acknowledgements

Some of the previously discussed elements have been collected in discussions/mail exchanges with Alistair Craib (Baric Consultants), David Daniels (ERA Technology Ltd), and Prof. John Smith (KCL London).

3.3 The Netherlands - Overview

3.3.1 Overall Evolution (Timeline)

Figure 3-5 and Table 3-3 illustrate the main actors, projects and the evolution of Humanitarian Demining RTD activities, and partly of military activities as well, in The Netherlands.

DUNBLAD	Delft University Neutron Backscattering Landmine Detector
GPR	Ground Penetrating Radar
HD	Humanitarian Demining
HOM2000	Dutch national demining programme
IPPTC	International Pilot Project for Technology Co-operation
ITC	International Institute for Geo-Information Science and Earth Observation
ITEP	International Test and Evaluation Program for Humanitarian Demining
MD	Metal Detector
MOD	Ministry of Defence
MOE	Ministry of Education
NBS	Neutron Back-Scatter
MOU	Memorandum of Understanding
RN	Royal Netherlands
STW	Dutch Technology Foundation
T&E	Test and Evaluation
TNO	Netherlands Defence Research Organisation
TNO-D&S	TNO-Defence, Security and Safety
TUD-IRCTR	Delft University of Technology International Research Centre for Telecommunications-transmission and Radar
TUD-IRI	Delft University of Technology Interfaculty Reactor Institute

Table 3-3 The Netherlands Glossary

In the following timeline (Figure 3-5) the top half details, in addition to some important political events and decisions, the different phases of the national HOM2000 project. The bottom half contains indications on R&D projects detailed in the gap to market case study section (top), on the TNO participation in European projects as well as on data collection and field trials (bottom).

An overall analysis of the Dutch demining R&D situation is reported in D4.2 (see also Section 5.3). Here we wish to briefly mention the following salient facts:

- Concerning early activities, ITC coordinated during 1998-1999 the Pilot project: Airborne Minefield Detection in Mozambique, a purely civilian activity supported by the DG Development and by several EU Member States (The Netherlands, Belgium, Luxembourg). This project culminated in a test campaign carried out in Mozambique, after several test flights over a testfield in Belgium (Leopoldsborg). ITC also coordinated the MINEDEMON (Mine Database Demonstrator) GIS project, supported by the DG Development in 1997.
- Still concerning early activities, test facilities at TNO were available as early as 1998 (supported by the MoD).

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- An updated MoD HD programme was launched in 2001 after the stop of the HOM2000 project phase 2. It terminated in 2005. HD related activities continue on a reduced scale (see Section 3.3.3), including ITEP involvement.
- TNO was involved in several European projects.

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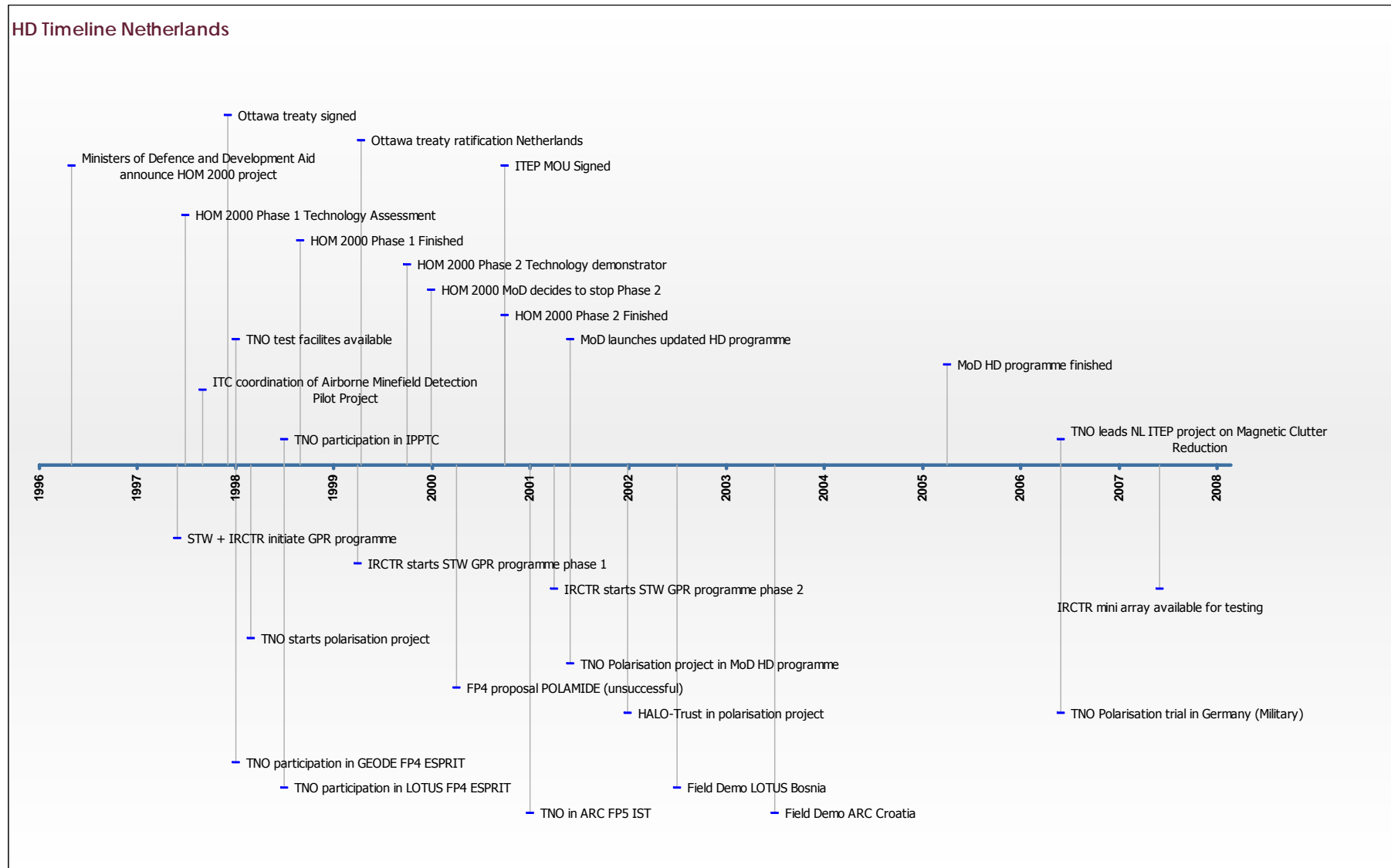
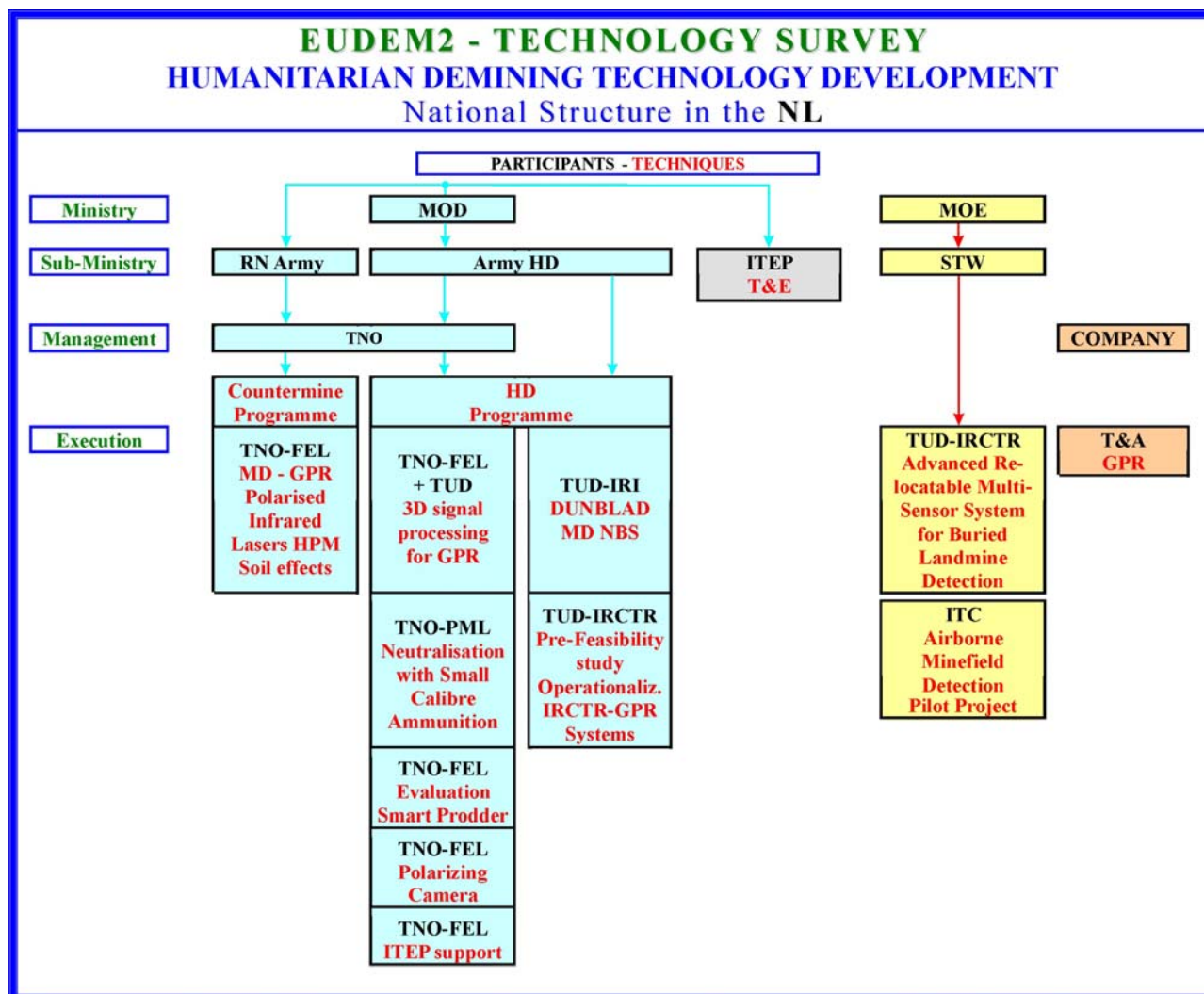


Figure 3-5 The Netherlands RTD Activities Timeline

3.3.2 2004 Organigramme

The financial/coordination aspects, as well as the relationship between the different projects, until 2004, are illustrated in Figure 3-2. The used abbreviations are provided in Table 3-3.

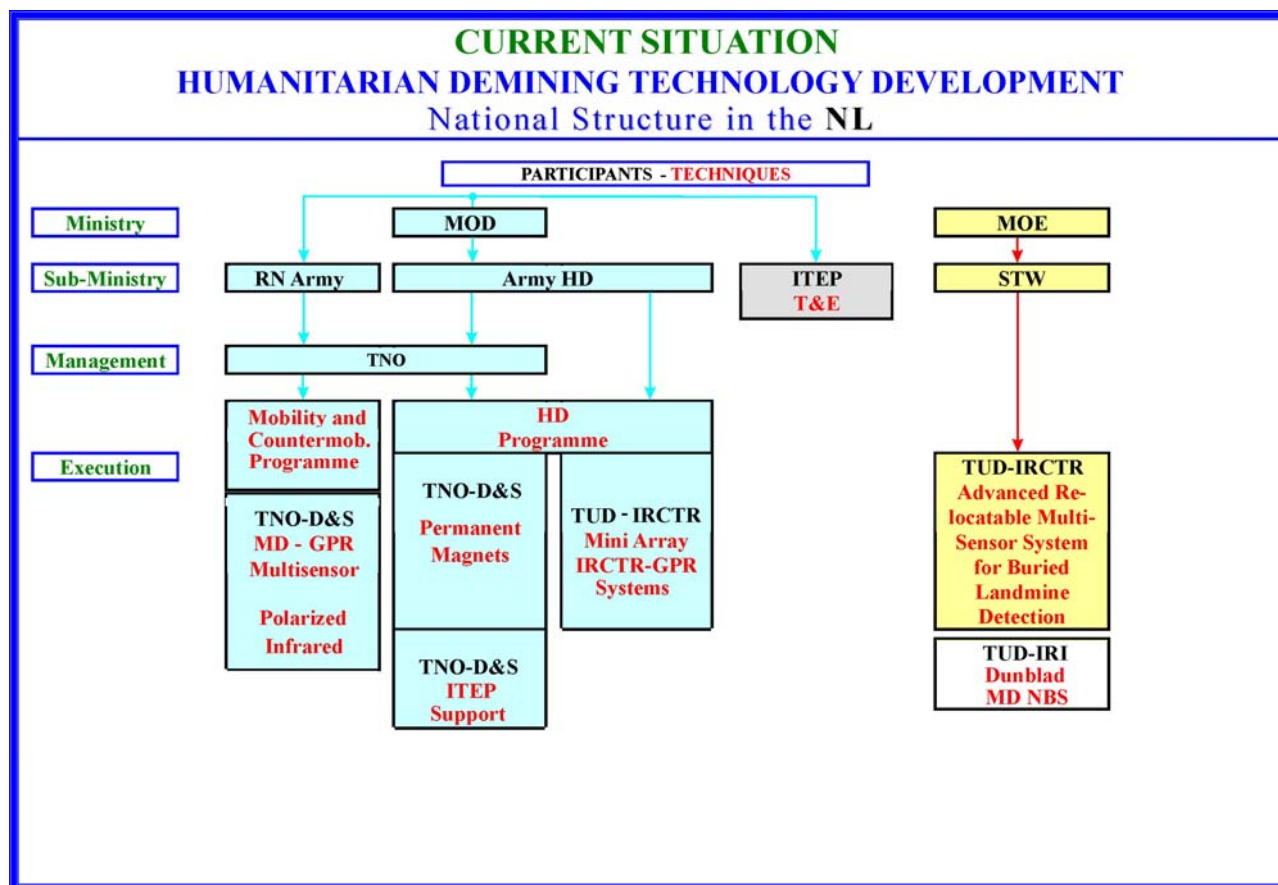


REMARKS: This overview is showing the past and running main programmes of the NL

Figure 3-6 Overview of the Netherlands National Projects – Situation until 2004

3.3.3 Current Situation

The current situation in The Netherlands is reported by means of an updated version of the previous organigramme (see Figure 3-7). The "Countermine" programme focuses now on "Mobility and Countermobility", whereas HD related activities continue on a reduced scale, including ITEP involvement. Selected R&D activities will be detailed in the "Success case studies" section (Section 5.3), and are not further investigated here.


LEGEND:

International	Military All-Levels	MOE	Industrial
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Version 5.1
02.03.2007

REMARKS: This overview is showing the running main programmes of the NL

Figure 3-7 Overview of the Netherlands National Projects – Current Situation

3.4 Belgium - Overview

3.4.1 Overall Evolution (Timeline)

Figure 3-8 illustrates the main actors, projects and the evolution of the Humanitarian Demining RTD activities in Belgium. The top half details some important political events and decisions. The bottom half contains indications on important Belgian R&D conferences (top), national as well as other relevant R&D projects, and data collection and field trials (bottom). Participations to a number of European projects have been omitted for the sake of clarity.

An overall analysis of the Belgian demining R&D situation is reported in D4.2. Here we wish to briefly mention the following salient facts:

- The top half of Figure 3-8 illustrates well Belgium's pioneering role in the fight against landmines since 1995, the bottom half the extensive involvement of Belgian organisations in HD related R&D activities.
- Belgium was the first country in the world to adopt a national legislation totally prohibiting anti-personnel mines (March 9th, 1995).
- Belgium has played since 2000 the role of coordinator of the "contact group" on transparency and exchange of information. Besides, Belgium has been three times (2000-2001, 2002,-2003 and 2005-2006) co-president of one of the four "Standing Committees" established under the Convention on the prohibition of anti-personnel mines.
- Concerning early activities, the Meerdal test site was available as early as 1997.
- The HUMANITARIAN DEMINING (HUDEM) national research project was launched in 1996 by the Belgian MoD and ended in 2002. The project was coordinated by the Royal Military Academy (RMA) and was carried out by researchers of eight Belgian universities (FUNDP, KUL, RUG, UCL, UIA, ULB, Ulg, VUB) and the Belgian Armed Forces (School of Engineers, the Explosive Devices Removal and Disposal Unit, and the Advanced Technology Department of the Army Technical Services).
- The Ministry of Foreign Affairs (Department of Development Aid) has been financing since 1999 a project concerning research towards the use of biosensors (giant African rats) for humanitarian demining, initiated by the NGO APOPO (AntiPersoonsmijn- Ontmijnings- en ProduktOntwikkeling). APOPO established its premises and training area at the Sokoine University of Agriculture (SUA), in Morogoro, Tanzania. In 2004, a first group of rats passed official licensing tests according to IMAS standards under the supervision of the Geneva International Centre for Humanitarian Demining (GICHD) and the National Institute for Demining in Mozambique (IND).
- Several Fundamental Research Projects have been financed as well in parallel to the aforementioned activities:
 - The Research Foundation – Flanders (Fonds Wetenschappelijk Onderzoek - Vlaanderen – FWO): "Stabilized deconvolution for inverse problems, applied to linear (Magnetic Resonance Imaging) and non-linear (Ground Penetrating Radar Imaging) Image reconstruction" (VUB-RUG),
 - The Vrije Universiteit Brussel (Concerted Research Action - Geconcerteerde Onderzoeksactie): "Numerical issues in tomographic shallow subsurface imaging with application to land mine detection"(VUB),
 - The Belgian Science Policy funded two projects under the TELSAT programme, namely the "RMA-Paradis project" and the "VUB-Change detection in Satellite Image Sequences for Area Reduction" project.
- The combined National, European and fundamental research projects resulted in more than 120 publications.
- Two Belgian research institutes, namely the Royal Military Academy (RMA) and the Vrije Universiteit Brussel (VUB), did participate to several European projects. This has been possible due to the national research projects.

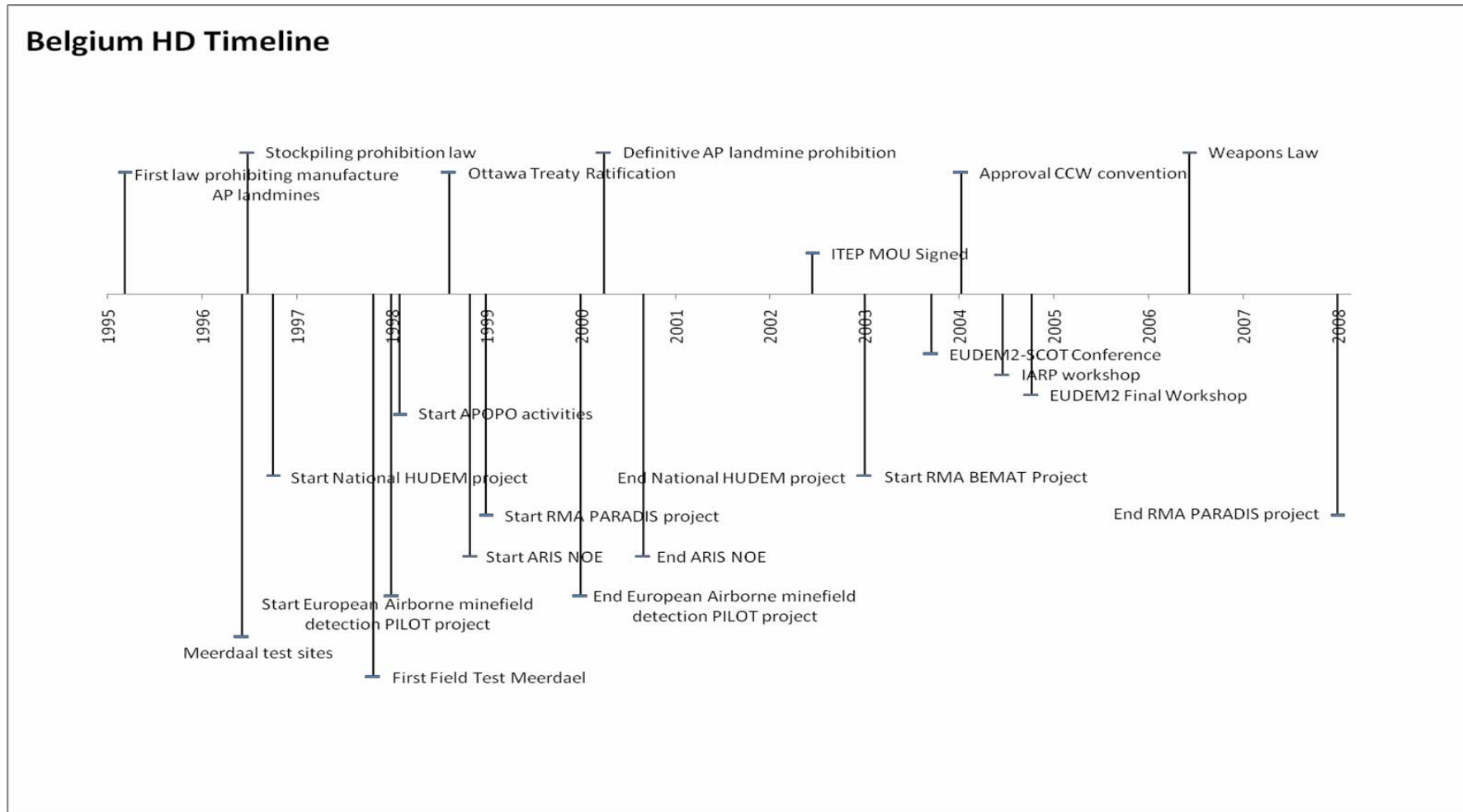


Figure 3-8 Belgian RTD Activities Timeline

3.4.2 Current Situation

The main National sponsored activities ended in 2004. The two main research actors, namely the Royal Military Academy (RMA) and the Vrije Universiteit Brussels (VUB), continue pursuing some fundamental research activities funded by their respective institutions. APOPO started investigating, in December 2004, a new project targeting the potential use of its technology for the detection of pathogens.

Acknowledgements

The overview of the Belgian situation and its analysis have profited from discussions with Marc Acheroy and Yann Yvinec (both RMA).

3.5 European Union - Overview

3.5.1 Overall Evolution (Timeline)

Figure 3-9 and Figure 3-10 illustrate the main actors, projects and the evolution of the Humanitarian Demining RTD activities in Europe, with inclusion of some international key events. The used abbreviations are provided in Table 3-4, the list of European co-funded projects in Table 3-5. The latter are also well covered in references such as [GAS2004] and [GAS2005], as well as on the DELVE website.

The timeline has been split in two parts purely for graphical reasons. As for most of the previous timelines, the top half contains in particular important political events, decisions and conferences, as well as some important international dates. The bottom half contains in particular indications on scientific conferences (top), European R&D projects and related calls (centre), and data collection and field trials (bottom).

An overall analysis of the European demining R&D situation is reported in D4.2. Here we wish to briefly mention the following salient facts:

- 1) Humanitarian Demining activities are usually understood as having started towards the end of the '80s in Afghanistan. In the early '90s political activities intensified: the International Campaign to Ban Landmines (ICBL) was formed in 1992, the 1st US "Hidden Killers" report released in 1993, the US HD programme started in 1995, UNMAS formed and GICHD funded in 1997, the original IMAS released in 1997, the Nobel peace prize assigned to ICBL and Jody Williams late 1997, CCMAT opened in 1998, etc., with a host of high level conferences taking place (in Europe: Copenhagen and Bonn in 1996, Karlsruhe and JRC Ispra in 1998, etc.).
- 2) The number of technical conferences did also intensify, from (in Europe) the early Montreux ICRC (1993) to the UN/FOA in Sweden (1994), to Edinburgh 1996 and 1998, the EUDEM2-SCOT conference in 2003, and the participation of European research institutes to the more defence oriented SPIE series in the US (annual, started in 1995 and still running), etc.
- 3) At European level a number of European Parliament and European Council resolutions were taken (see the top part of the timelines). As one of the consequences a number of R&D projects were launched over the years. Initial tenders were gradually replaced by "traditional" FP calls, with a few exceptions such as the Airborne Minefield Detection Pilot Project (see also D4.2).
- 4) The overall political process culminated in the Ottawa Treaty, which entered into force in 1999, and the 1st Meeting of the States Parties in Maputo (1999).
- 5) The subsequent "waves" of European projects are clearly visible from the timeline as well as from the 2004 Organigramme in Section 3.5.2. They led to test and evaluation of increasingly mature systems, e.g. the Pilot Project in Mozambique, the Croatian flight campaigns of the ARC and SMART airborne projects, or the extensive testing activities of the BIOSENS trace explosive detection system (2002-2004).
- 6) At international level standardisation efforts were intensified, as well as test and evaluation activities, in particular via ITEP (MoU signed in 2000). The latter included as from 2004-2005 tests of quite mature dual sensor hand-held systems, including in real minefields.
- 7) At the R&D level the subject started however gradually to lose importance as from around 2004, being mostly taken over by security related issues and environmental risk management as a whole. This is also indicated by the appearance of conferences dealing jointly with security and demining (e.g. Lake Bled in 2003), the first PASR call in 2004, the last set of European projects dealing with demining already within the environmental risk management umbrella (started late 2004). In Europe JRC ended its involvement in HD activities in 2006, R&D was not explicitly mentioned in the EP resolution on a "mine-free world" any more (2006), and in Canada the Canadian Center for Mine Action Technologies (CCMAT)¹² closed early 2007.

¹² http://www.suffield.drddc.gc.ca/Facilities/CCMAT/index_e.html

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ACP	African, Caribbean and Pacific States
APL	Anti-personnel landmines
ARIS	Action for Research and Information Support in Civilian Demining (European support measure)
CCMAT	Canadian Center for Mine Action Technologies
CEN	European Committee for Standardization
CEN CW07	CEN Workshop 7, "Humanitarian Mine Action – Test and Evaluation - Metal Detectors"
CW(A)	CEN Workshop (Agreement)
CIMIC	Multi-sensor equipment for landmine detection in civil mine clearance operations (European project)
DG	Directorate General (European Commission)
EC	European Commission
EP	European Parliament
EU	European Union
FOA (now FOI)	Swedish Defence Research Establishment
FP	Framework Programme for research and technological development (European Commission)
GICHD	Geneva International Centre for Humanitarian Demining
GIS	Geographic Information System
HPCN	High Performance Computing and Networking (EC FP4)
IARP	International Advanced Robotics Programme
ICRC	International Committee of the Red Cross
IEE	Institute of Electrical Engineers (UK)
IMAS	International Mine Action Standards
IMSMA	Information Management System for Mine Action (GICHD)
IPPTC	International Pilot Project for Technology Co-operation
ITEP	International Test and Evaluation Programme
JRC	Joint Research Centre of the European Commission
(JMU) MAIC	Mine Action Information Center at James Madison University
MDD'99	Global Workshop on Mine Detecting Dogs, Ljubljana, Slovenia, 1999
MINE'99	Mine Identification Novelties Euroconference, Florence, 1999
MOU	Memorandum of Understanding
NoE	Network of Excellence
NVESD	Night Vision and Electronic Sensors Directorate (US Department of Defense, Fort Belvoir, VA)
PASR	Preparatory Action in Security Research (European Commission)
RAND report	"Alternatives for Landmine Detection" report, RAND Corporation, 2003
SPIE	The International Society for Optical Engineering
T&E	Test and Evaluation
UN	United Nations

UNDHA	United Nations Department of Humanitarian Affairs
UNMAS	United Nations Mine Action Service
US	United States of America
WAPM	Workshop on Anti-Personnel Mine Detection and Removal
WTC	World Trade Center (New York)

Table 3-4 EU Glossary

Acronym	Name	Start Date	End Date	Details
PICE	Pinpoint, Identification Clearance and Ensurance	1/1/1999	31/12/2000	The PICE project focused on the realisation of a safe and cost-effective man-portable multi-sensor anti-personnel mine detection system, based on a Metal Detector (MD) in combination with a Ground Penetrating Radar (GPR).
ARIS	Action for Research and Information Support in civilian demining	1/11/1998	30/4/2000	The ARIS NoE supported the technological innovation to match specific operational needs by promoting interaction with users through seminars on current and future R&D areas.
MINESEYE	Development and Optimization of a dual sensor system with real time digital signal processing for the detection and identification of buried landmines and unexploded Ordnance	1/1/1999	30/6/2001	Development and Optimization of a dual sensor system with real time digital signal processing for the detection and identification of buried landmines and unexploded Ordnance.
MINETEST	Testing of Sensors and Systems in Support to Humanitarian Demining	1/12/1997	30/11/2001	The main work under this contract has been to provide an independent assessment facility to validate and benchmark the performance levels achieved by the consortia contracted under ESPRIT to develop equipment, systems and algorithms related to improved civilian demining tools.
HOPE	Hand-held Operational Demining System	1/1/1999	30/6/2001	The HOPE project aimed at developing a hand-held multisensor system combining a GPR an advanced metal detector and a radiometer.
DEMINE	Improved cost-efficient surface penetrating radar detector with system on chip solution for humanitarian demining	1/2/1999	31/1/2001	The Project aimed at developing a new hand-held GPR array system with the following characteristics: <ul style="list-style-type: none"> Revolutionary system on chip solution based on high speed digital technology. Antenna array for multi-static and multi-polarisation techniques. Dynamic positioning measurement system. Multi-dimensional signal processing and classification which exploits the novel features of the radar.
LOTUS	Light ordnance detection by teleoperated unmanned system	1/2/1999	31/1/2002	The LOTUS PLUS system consisted in developing a vehicle with a metal detector, an infra-red camera, and a ground penetrating radar. As the vehicle moves forward the position of targets detected will be marked and the data stored to allow more extensive evaluation off-line between the real-time search and any subsequent mine clearance operation. The output for the LOTUS PLUS project was a demonstration of detection capability.
BULRUSH	Humanitarian Demining in Water	1/1/2001	28/2/2002	The project objectives have been to validate a vehicle-based sensor system for Humanitarian Demining in water that has the potential to offer a quantum increase in capability and productivity, Thomson Marconi Sonar SAS designed a prototype demining system exploiting Guigné's modular mine-detection and identification sonar components.

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ARC	Airborne Minefield Area Reduction	1/1/2001	6/30/2003	The objectives of the ARC project were to consolidate and extend previous experiences and know-how acquired in airborne survey R&D projects for Minefield Area Reduction. This was achieved by using an existing low-cost helicopter drone and a combination of existing and new sensors. More specifically an advanced improved Multispectral & IR data analysis and innovative fusion techniques were combined. An Information System, integrated in the ARC concept and including an advanced GIS, allowed for fusion of measured image data, a priori information and geographical information. The ARC system was targeted at achieving accurate and effective results for minefield area reduction in order to facilitate the Level 2 survey in a way which is acceptable for MAC's and Demining Organisations. The very same approach could be used for Quality Control.
BIOSENS	Vapor Detection - Area Reduction in Demining	1/1/2001	31/12/2003	The BIOSENS project aimed to develop a Biosensor system, a vapour detector sometimes called "the artificial dog's nose", able to find the smallest quantities of explosives in the mines. The goal was that in time the system would revolutionize demining in South East Europe and in the whole world.
DEMAND	Enhancement of the three existing technologies Data fusion algorithms for the test Demonstration of Multi-Sensor Landmine Detection Techniques	1/2/2001	31/7/2003	The main work in the project has been the building and integration of the four main components of the system (MD array, GPR array, Biosensor and data fusion). All components came from previous technological developments and, in a number of cases, precisely from Humanitarian Demining. The GPR array and the data fusion were based on the feasibility study of the EUREKA! ANGEL project; the GPR core technology has been an improvement from the RTD DEMINE project for Humanitarian Demining funded under the EC 4th Framework Programme; and the MD was an enhancement of a commercially available and tested demining sensor.
DIAMINE	Detection and Imaging of Antipersonnel Landmines by Neutron Backscattering	1/1/2001	31/12/2003	The objective of DIAMINE has been the development of a prototype of hand-held landmine detector using the neutron back-scattering technique. A low-activity source (^{252}Cf , about 10^5 fast neutron/second) was selected to irradiate the soil.
SMART	Space- and Airborne Mined Area Reduction Tool	1/6/2001	31/5/2004	SMART aimed at using airborne minefield survey and developing tools for helping the human analysts in their interpretation tasks for mine suspected area reduction. The data collection module of SMART consisted in the organisation of an airborne campaign (active full polarimetric SAR and passive multi-spectral sensors), the gathering of existing spaceborne data and the collection of ground-truth data, expert knowledge and context information.
EUDEM2	The EU in humanitarian DEMining, Phase 2. State-of-the-art on Humanitarian Demining Technologies, Products, Services and Practices in Europe	1/1/2002	31/12/2004	EUDEM2 aimed at supporting the EU RTD&D consortia and policy makers, and the Humanitarian Demining community. The approach was an active one, whereby actors were contacted directly either by interviews, questionnaires, demands for inputs to the knowledge data base and for participation to workshops.
CLEARFAST	Concept for Low-risk Efficient Area Reduction based on the Fusion of Advanced Sensor Technologies	1/1/2001	30/6/2005	CLEARFAST phase 1 proposed a transportable mast-mounted MSIR sensor and a multisensor platform mounted on a vehicle. Both systems were based on the requirements of a two-phase Level 2 survey model. During the second phase of the project, focus was on the use of MSIR for area reduction, including a field test in Cyprus in real mine fields.

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STREAM	Technology to Support Sustainable Humanitarian Crisis Management	1/12/2004	30/06/2008	<p>The project's goals are two fold, namely the development of (1) products, and (2) procedures for end-to-end technological platforms and tools for survey and decision support in humanitarian crisis:</p> <ul style="list-style-type: none"> o Mission planning and management, for space-/air-borne and field survey. o Mobile Computing Infrastructure for field survey including ground truth acquisition and verification tools. o Remote sensing data analysis and interpretation. o Information Management and Decision Support System for structuring, analyzing, synthesizing the acquired data and knowledge. o Information Communication and Broadcasting.
DELVE	Restructuring Demining Research from Regional Initiatives within Europe	1/12/2004	31/03/2007	<p>Given the take-up gap for European technology it is of interest produce</p> <ul style="list-style-type: none"> o Detailed summary of the ending of the R&D project funding in Europe and a thorough analysis of the reasons why this has happened o Analysis of the lessons learned which seeks to apply the results of the analysis prospectively to future R&D in the broad field of ICT for risk/crisis management, and provide useful support in defining the ToR for Risk and Crisis management for FP7 o Seek for cooperation and develop synergy between RELEX, AIDCO, and INFSO in support of the previous objectives
RESCUER	Improvements of the Emergency Risk Management through Secure Mobile Mechatronics Support to Bomb Disposal and Rescue Operation	1/12/2004	30/04/2008	<p>RESCUER focuses on the development of an intelligent Information and Communication Technology and mechatronic Emergency Risk Management tool and on testing it in five Improvised Explosive Device Disposal, and Civil Protection Rescue Mission scenarios. The project outputs include guidance for management of risk, which extends the range of interventions possible beyond those which are currently considered. The extended range of interventions will include tasks which are too risky at present to commit human involvement, tasks where access might not be possible without ICT and mechatronic support, especially in EOD, IEDD, significant toxic/radiation/flammable/explosive contamination, mechanical failure and other relevant hazardous situations or combinations of hazards.</p>

Table 3-5 EC-IST Co-funded projects

DELVE

Restructuring Demining rEsearch from Regional initiatives within Europe

HD European & International Timeline, Part 1

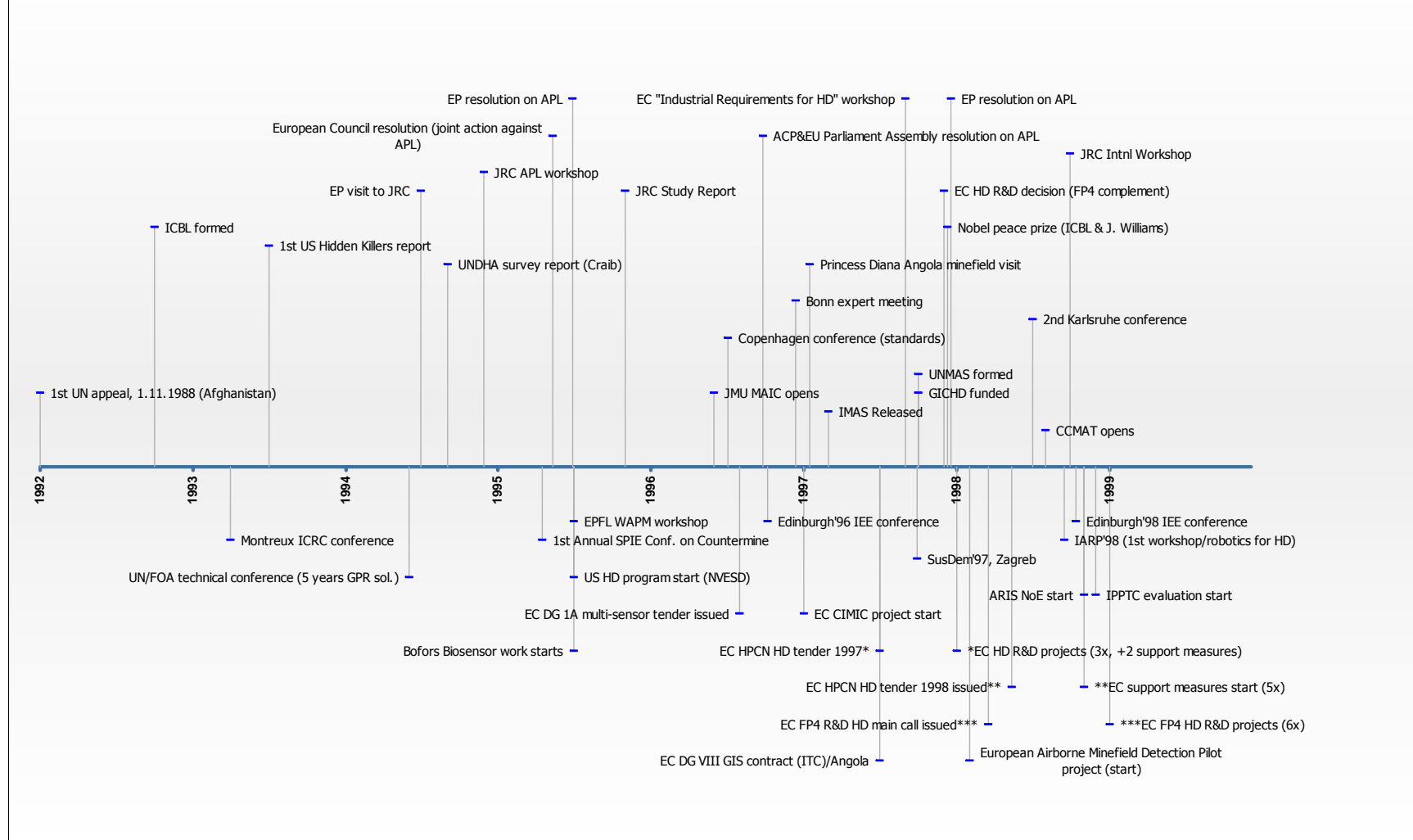


Figure 3-9 EU RTD Activities Timeline – Part 1

Restructuring Demining research from Regional initiatives within Europe

HD European & International Timeline, Part 2

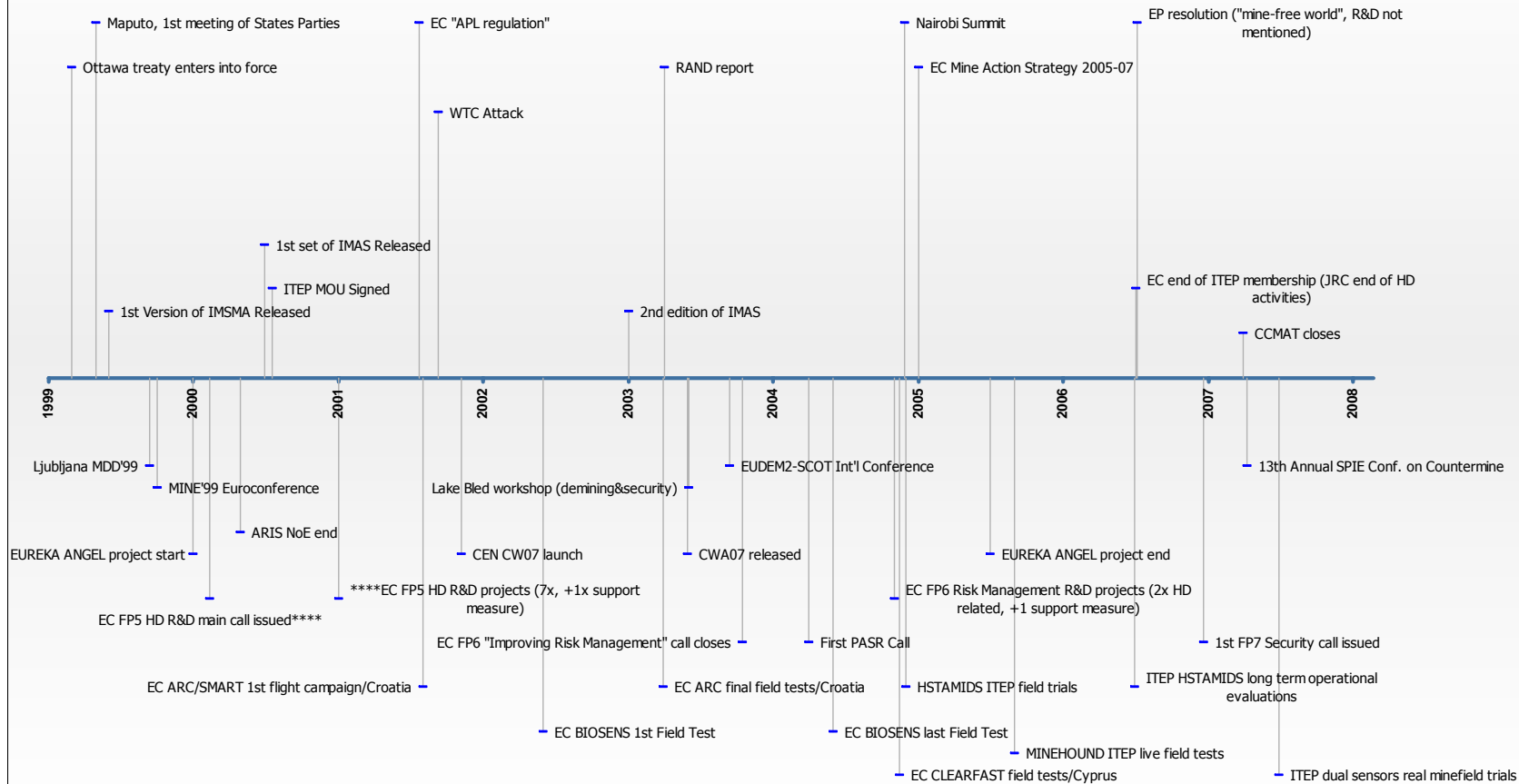
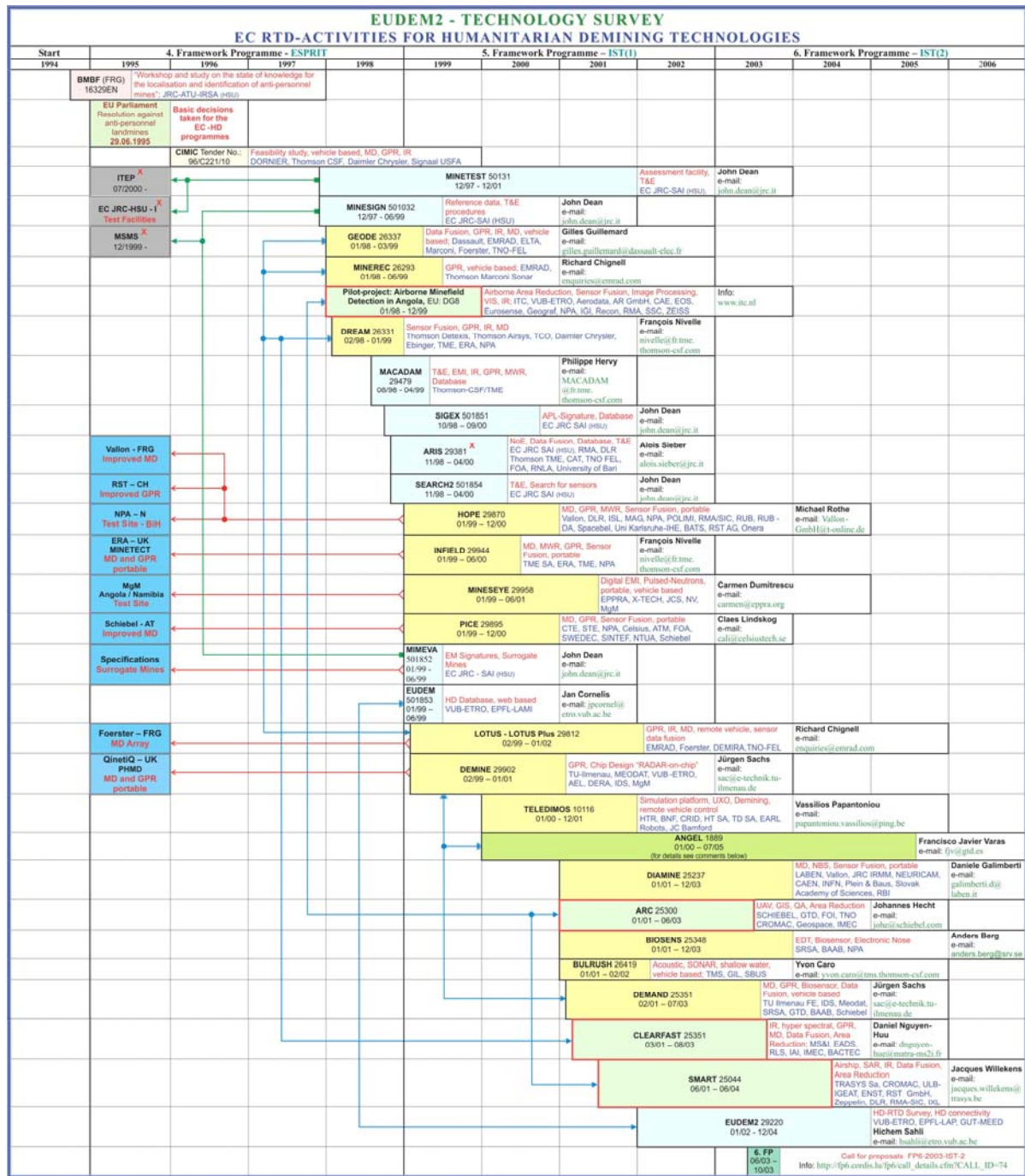


Figure 3-10 EU RTD Activities Timeline - Part 2

3.5.2 2004 Organigramme



3.5.3 Current Situation

At the EC R&D level the subject started to lose importance as from around 2004, being mostly taken over by security related issues (DG JRC - Institute for the Protection and Security of the Citizen) and environmental risk management as a whole (DG Information Society and Media). The current reduction of the EU Humanitarian Demining research programme and its incorporation into the wider "Improving Risk Management" strategic objective, which was foreseen as a way of generating synergies with other types of responses to humanitarian crises management, where technologies such as Information Management, Geographical Information Management and Earth Observation are more likely to be used in a 'System Approach', did not generate the expected synergies. Only two STREPs including some Humanitarian Demining related goals, namely STREAM and RESCUER, and the DELVE support measure, have been funded under the 2003 IST FP6 "Improving Risk Management" call.

Concerning the DELVE project itself, its original objectives had been defined under the assumption that it would be running in parallel to a number of R&D projects for the development of humanitarian crises management technologies. The overall goal was to generate synergy between these projects and national programmes in the various European countries. However, as outlined above the unexpected outcome of the evaluation of the proposals was that there would be no projects in FP6 *specifically* aiming at technology for Humanitarian Demining. From the work package on assessment of the European R&D situation conducted during the first year of the DELVE project, it also became clear that the national research activities were strongly decreasing in size. For these reasons *the opportunities for synergy anticipated in DELVE did no longer exist.*

3.6 Japan – Overview

Japan has been selected as non-European case study as we see interest in the Japanese approach which has made it possible, by a concerted effort, to bring a number of systems to the field test phase, to scientifically evaluate their detection performance comparing it with currently used metal detectors, and publish the results. This is detailed in the gap to market case study Section 5.2.

3.6.1 Overall Evolution (Timeline)

Figure 3-11 and Table 3-6 illustrate the main actors, projects and the evolution of the Humanitarian Demining RTD activities in Japan. A detailed timeline is provided in tabular form in Table 3-7.

Abbreviations	
APL	Anti-personnel landmines
CMAC	Cambodian Mine Action Centre
GICHD	Geneva International Centre for Humanitarian Demining
GPR-EMI	Ground Penetrating Radar – ElectroMagnetic Induction
ITEP	International Test and Evaluation Programme
JAHDS	Japanese Alliance for Humanitarian Demining Support
JST	Japan Science and Technology Agency
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MOFA	Ministry of Foreign Affairs
ODA	Official Development Assistance
SCJ	Science Council of Japan
UNMACA	UN Mine Action Centre for Afghanistan

Table 3-6 Japan Glossary

In the following timeline (Figure 3-11) the top half details, in addition to some important political events and decisions, several activities which accompanied the ongoing R&D projects (from the Afghanistan field visit in 2002 to the workshop with Afghanistan NGOs in late 2003). The bottom half details the main R&D projects, all the way to the final project demonstration and workshop events, together with other relevant data collection and field trial activity (bottom) and workshops (top).

An overall analysis of the Japanese demining R&D situation is reported in D4.2 (see also Section 5.2). Here we wish to briefly mention the following salient facts:

- It is interesting to follow the decision process which led, from the Tokyo APL conference in 1997, to the signature and ratification of the Ottawa Treaty in 1998, the SCJ report in early 2000, the new framework for APL clearance in late 2000, all the way to the actual call for proposal in 2002 and the subsequent start of the individual projects.
- Activities carried out in parallel but independently include work by the GeoSearch company on a GPR imaging prototype ("Mine Eye") and subsequent field tests. This is partly the case for the hand-held GPR and MD system developed by COS Co. Ltd.

Restructuring Demining Research from Regional Initiatives within Europe

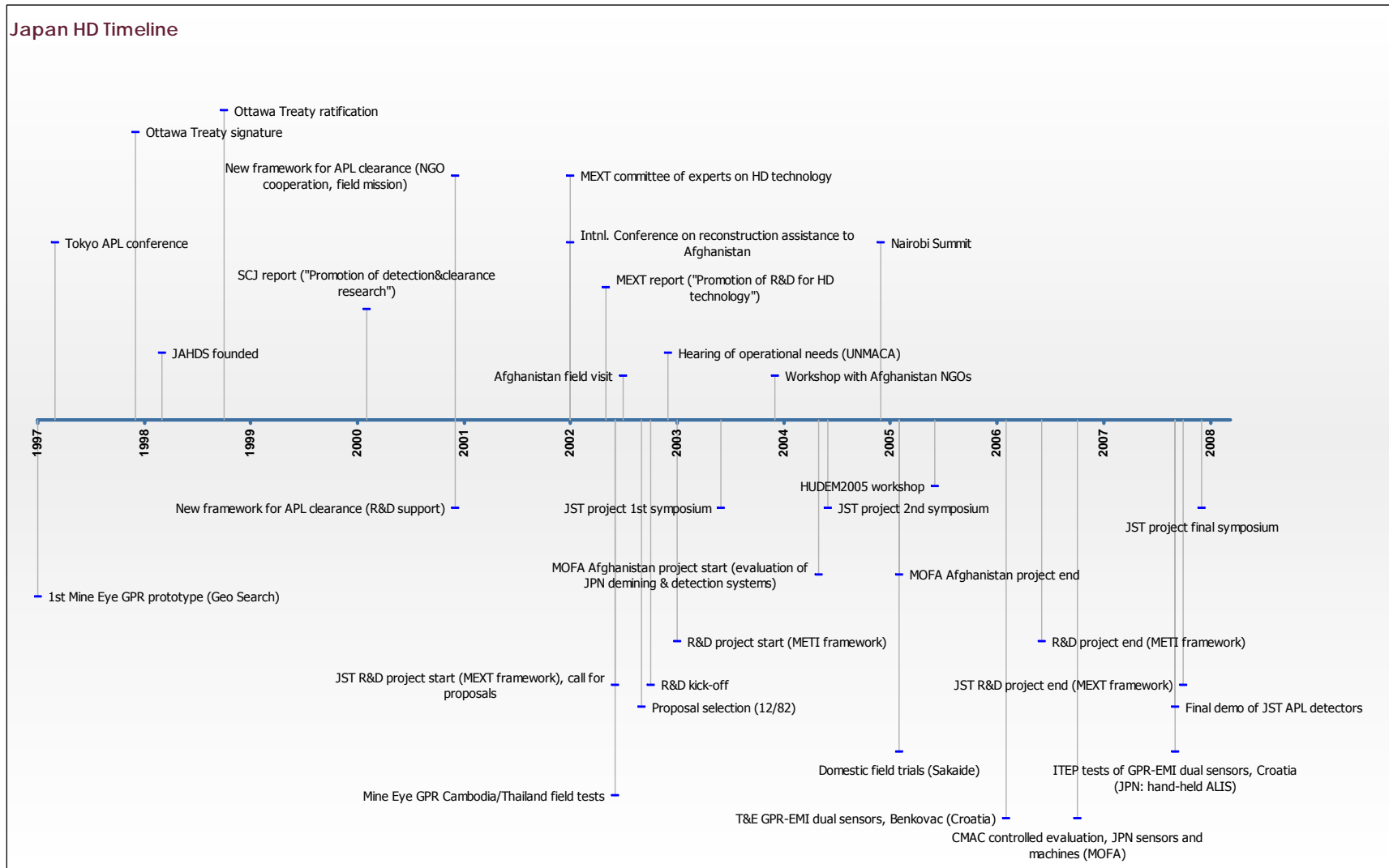


Figure 3-11 Japan RTD Activities Timeline

DELVE

Restructuring Demining Research from Regional Initiatives within Europe

The following detailed timeline was provided by J. Ishikawa, JST [ISH2007]. The left part is relative to the Japanese activities as a whole, the right one is specific to the JST activities.

Japan				JST Project		
Start	End	Events	Comments	Event	Comments	Related JST devices
March 1997		Tokyo Conference on Anti-Personnel Landmines	"Tokyo Guidelines"			
December 1997		The signing conference of the Ottawa Convention	Mr. Keizo Obuchi, the then Minister for Foreign Affairs of Japan, signed the Total Ban Treaty on Anti-Personnel Mines (Ottawa Treaty), and the "Zero Victim Program" was proposed.			
February 2000		Issued Report entitled "On the Promotion of Research on Humanitarian Landmine Detection and Clearance Technology" by SCJ				
December 2000		New Framework for anti-personnel mine clearance	Support for R&D of Demining Technology. Support for laboratory work for new technology. Strengthened cooperation with NGOs. Dispatch of a field mission composed of government and private sector staff.			
January 2002		International Conference on Reconstruction Assistance to Afghanistan in Tokyo	Opening Statement by the then Prime Minister Koizumi (extract): "Japan will mobilize its resources to develop demining technologies."	Set up the Committee of Experts on Humanitarian Demining Technology by MEXT		
May 2002				Issued Report entitled "Promoting R&D for Humanitarian Demining Technology" by MEXT		

DELVE

Restructuring Demining Research from Regional Initiatives within Europe

Japan				JST Project		
Start	End	Events	Comments	Event	Comments	Related JST devices
June 2002				Start of the JST R&D project under the MEXT framework	Call for Research Proposals by JST	
July 2002				On-the-spot Investigation in Afghanistan	MOFA, MEXT, METI and Ministry of Defense	
September 2002				Selected 12 proposals out of 82	by JST with cooperation of GICHD(Mr. P. Blagden), UNMACA (Mr. H. Javed) and Japanese advisers	
October 2002				R&D kick-off		
December 2002				Invited Mr. Richard D. Kelly, Director of UNMACA, for hearing of operational needs		
January 2003		Start of the R&D project under the METI framework				
June 2003				the 1st Symposium of the JST Project		
December 2003				a workshop with Afghanistan Mine Action NGOs		
May 2004	February 2005	Research Project for Developing Mine Clearance Related Equipment in Afghanistan (MOFA)	Evaluation test of Japanese demining and detection machines in the field in Afghanistan.			Tests including Hand-Held ALIS
June 2004				the 2nd Symposium of the JST Project		
August 2004				Had a Visit of Dr. Sharif Fayes, Minister of Higher Education for the Transitional Islamic State of Afghanistan		
December 2004		the Nairobi Review Conference of the Ottawa Convention	"Japan's New Policy on Anti-Personnel Mines"		Held a booth with posters to introduce the JST project	

DELVE

Restructuring Demining Research from Regional Initiatives within Europe

Japan				JST Project		
Start	End	Events	Comments	Event	Comments	Related JST devices
February 2005	March 2005			Domestic field trial in Sakaide, Japan		Gryphon+ALIS, SAR-GPR (MHV#1), LAMDAR-II(MHV#2) and Advanced Mine Sweeper (AMS)
June 2005				the International workshop on Robotics and Mechanical Assistance in Humanitarian Demining (HUDEM2005)		
February 2006	March 2006			Joint Test and Evaluation of Japanese GPR-EMI dual sensor systems at Benkovac Test Site in Croatia		Hand-Held ALIS, Gryphon+ALIS, SAR-GPR (MHV#1), LAMDAR-III (MHV#2)
October 2006	January 2007	Evaluation test of Japanese Sensor Systems and Demining Machines under control of the Cambodian Mine Action Center (MOFA)				Tests including Hand-Held ALIS, Gryphon+ALIS and LAMDAR-III (Stand alone)
September 2007				ITEP evaluation tests for GPR-EMI dual sensors in Croatia	Comparative trials for dual sensors of Japan, U.S.A. and U.K.	Hand-Held ALIS
September 2007				Final Demonstration of JST AP Landmine Detection Sensor Systems in Japan		Hand-Held ALIS, LAMDAR-III, Gryphon, AMS, and explosive sensors based on TNA and NQR
October 2007				Termination of the JST project		
December 2007				Final Symposium of JST AP Landmine Detection Sensor Systems in Japan		

Table 3-7 Japan Detailed Timeline

3.6.2 Main National Activities

The recent Japanese Humanitarian Demining related R&D situation is characterised by the existence of three projects under three different ministries, working in cooperation with each other.

MEXT:

Discussions between relevant government agencies on how to support Humanitarian Demining related R&D have been ongoing since 2000 [SAT2006]. MEXT published a report on "Promoting R&D for Humanitarian Demining" in May 2002, and soon thereafter started its demining oriented R&D project (for full details see the timeline in Figure 3-11 and Table 3-7). The latter is actually composed of six R&D projects aimed at short- to medium-term solutions (in particular hand-held and vehicle-based GPR systems, search vehicles and support systems¹³), as well as three medium- to long-term solutions (neutron, gamma ray and NQR explosive detection systems) [SAT2006]. Funds have been allocated to universities and companies, and the projects are targeted at **new** technologies [MASG2005].

METI:

In parallel, as from January 2003 METI provided support for six R&D projects, of more applied nature than the MEXT-sponsored ones, and aimed at developing portable antipersonnel mine detectors, landmine detection vehicles, and demining machinery¹⁴. Funds have been allocated to companies, and the projects are targeted at **existing** technologies [MASG2005].

MOFA:

The MOFA provided support for T&E in Afghanistan of nine machines from seven groups, via the Japan International Cooperation System (JICS), from May 2004 to February 2005 [JICS2005]. This included mechanical demining machinery, which is expected to be adopted by Afghanistan and Cambodia according to [SAT2006]. Similar tests have taken place between October 2006 and January 2007 in Cambodia, under control of CMAC.

These three main sub-projects and their key results can be detailed as follows [ISH2007]:

1. "Research and Development of Sensing Technology, Access and Control Technology to Support Humanitarian Demining of Anti-personnel Mines." [MEXT]

- Sponsoring body: Ministry of Education, Culture, Sports, Science and Technology (MEXT)
- Implementing organization: Japan Science and Technology Agency (JST)
- Timeframe: October 2002 - October 2007
- Objective: research the feasibility and develop experimental prototypes of dual sensor systems based on advanced technologies.
- Main results:
 - Developed prototypes of GPR-MD dual sensors and executed the Afghanistan and Cambodian field trials.
 - ALIS will undergo a comparative test by ITEP, in Croatia during Sept. 2007, together with HSTAMIDS (US) and MINEHOUND (UK/Germany).
 - A pre-production version of ALIS will be available at the end of the JST project.
 - Clarified feasibility of a thermal neutron and an NQR explosive detection method.

¹³ ALIS (Advanced Landmine Imaging System) GPR, LAMDAR-III impulse SAR GPR and metal detector, Tohoku Univ. SAR GPR and metal detector [BRU2006]; Mine-Hunter vehicle (MHV) [BRU2006], Advanced Mine Sweeper (AMS), Gryphon buggy.

¹⁴ Kawasaki MINEDOG detection vehicle (GPR based) [BRU2006], Cos Sencion GPR+MD hand-held detector; Yamanashi Hitachi Construction Machinery (flail hammer type or rotary cutter type), Komatsu (heavy duty type or light weight type), Kawasaki MINEBULL (with tiller).

A public demonstration is planned before the end of the project in Japan (mid-September), followed by a symposium on December 3rd, 2007.

2. "Development of detection and removal technology for buried objects."

- Sponsoring body: Ministry of Economy, Trade and Industry (METI)
- Implementing organization: New Energy and Industrial Technology Development Organization (NEDO)
- Timeframe: 2003-2006
- Objective: develop practical prototypes of demining machines and dual sensor systems based on existing technologies.
- Main results:
 - Developed prototypes of demining machines (and sensors) and executed the Afghanistan and Cambodian field trials.
 - Deployed some machines in mine-affected countries.

3. "Research Project for Developing Mechanical Demining Machines in Afghanistan." [JICS2005]

- Sponsoring body: Ministry of Foreign Affairs (MOA).
- Implementing organization: Japan International Cooperation System (JICS)
- Timeframe: 2002-2005
- Objective: evaluate prototypes of demining machines and dual sensor systems in cooperation with the UN Mine Action Center for Afghanistan (UNMACA).

3'. "Evaluation test of Japanese Sensor Systems and Demining Machines under control of the Cambodian Mine Action Center (CMAC)"

- Sponsoring body: Ministry of Foreign Affairs (MOA)
- Implementing organization: Japan International Cooperation System (JICS)
- Timeframe: 2006-2007
- Objective: evaluate prototypes of demining machines and dual sensor systems in cooperation with CMAC.

Concerning the last point, three dual-sensor systems were tested under the use of local deminers in Cambodia.

Other field tests

Some of the MEXT-sponsored sensors and systems have been tested at the beginning of 2006 in Benkovac, Croatia.

The ALIS system has been demonstrated in Italy and Sweden and will undergo comparative trials under the banner of ITEP, in Croatia during September 2007. ALIS also underwent validation tests in Croatia and Egypt [SAT2006].

Other Japanese HD R&D activities

Other sensing systems projects have taken place in Japan, although relatively little is often known. Amongst them [BRU2006]:

- GeoSearch developed a hand-held imaging GPR prototype as early as 1997 ("Mine Eye" system), and field tested an enhanced version in Cambodia/Thailand in 2002.
- COS Co. Ltd. developed the Sencion hand-held MD+GPR system, which was probably tested in Cambodia (in addition to the previously mentioned Afghanistan tests).

3.6.3 Accompanying Notes

Decision making process (MEXT):

- The budget is approved by the MEXT year by year. The JST research supervisor and the board committee decide a plan for one year.

Route to deployment:

- In Japan, mine detection systems are classified as a kind of weapon and are therefore under a strict embargo control by the METI; export licenses are however relatively easily issued for MOFA's projects. As far as deployment is concerned, a concerted effort is therefore needed.
- The only way to deploy Japanese demining systems is actually as Official Development Assistance of the MOFA based on a request by a mine-affected country. This is reported to have worked well in some cases, for example for demining machines.

Acknowledgements

Some of the previously discussed elements, in particular the three main sub-projects and their key results, have been collected in discussions/mail exchanges with Jun Ishikawa, JST, and Prof. M. Sato (Tohoku University) during his visits to Brussels.

4 R&D KEY SUBJECTS - BIBLIOMETRIC STUDY

4.1 Methodology and Results

During the past 10 years, a number of technical conferences have been organized in Europe: the early Montreux ICRC (1993), the UN/FOA in Sweden (1994), Edinburgh 1996 and 1998, Firenze 1999, EUDEM2-SCOT¹⁵ in 2003, a number of workshops and conferences organized by the DG JRC within the framework of the ARIS network¹⁶, as well as several conferences with special sessions on demining technologies.

In order to analyse how the key R&D topics in demining related research evolved during the past 10 years, we selected the yearly *SPIE US conference on "Detection and Remediation of Mines and Minelike Targets"*. It is acknowledged that this conference is largely US oriented, heavily influenced by defence sponsored work, and partially suffering from a lack of end-user input. However, this event was the only one which ran (and still runs) yearly since 1995, greatly facilitating comparisons and the analysis of trends, with most results being applicable as well to demining R&D carried out in Europe, also because the main European organizations involved in HD R&D did and still do contribute to the conference.

This analysis is based on the indexes of the published proceedings, which are also available from the SPIE website¹⁷, rather than on the initial conference programmes. Also, *the 2007 proceedings have not yet been printed; the corresponding numbers should therefore be considered as provisional.*

The following charts (Figure 4-1 and Figure 4-2) depict, in absolute and relative terms, respectively, the number of papers which were published in the yearly SPIE conference proceedings, subdivided per subject category (the latter having been defined by ourselves). **Note that the 2007 figures are provisional.**

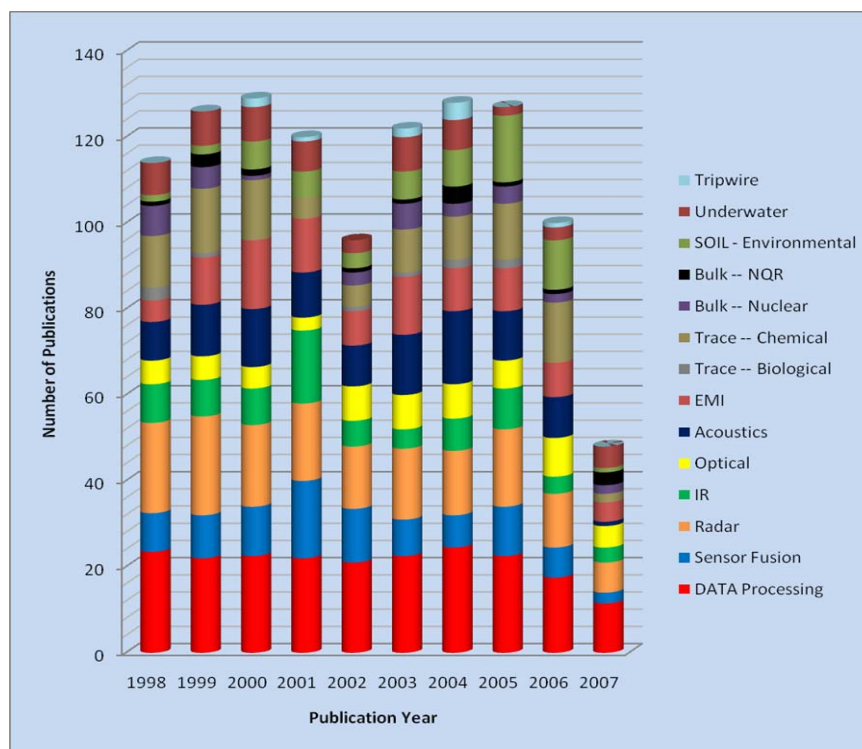


Figure 4-1 Absolute number of SPIE proceedings publications per category

¹⁵ <http://www.eudem.vub.ac.be/eudem2-scot/>

¹⁶ <http://demining.jrc.it/aris/>

¹⁷ <http://spie.org/x399.xml> -> search for "minelike" in "Conference Proceedings Volumes".

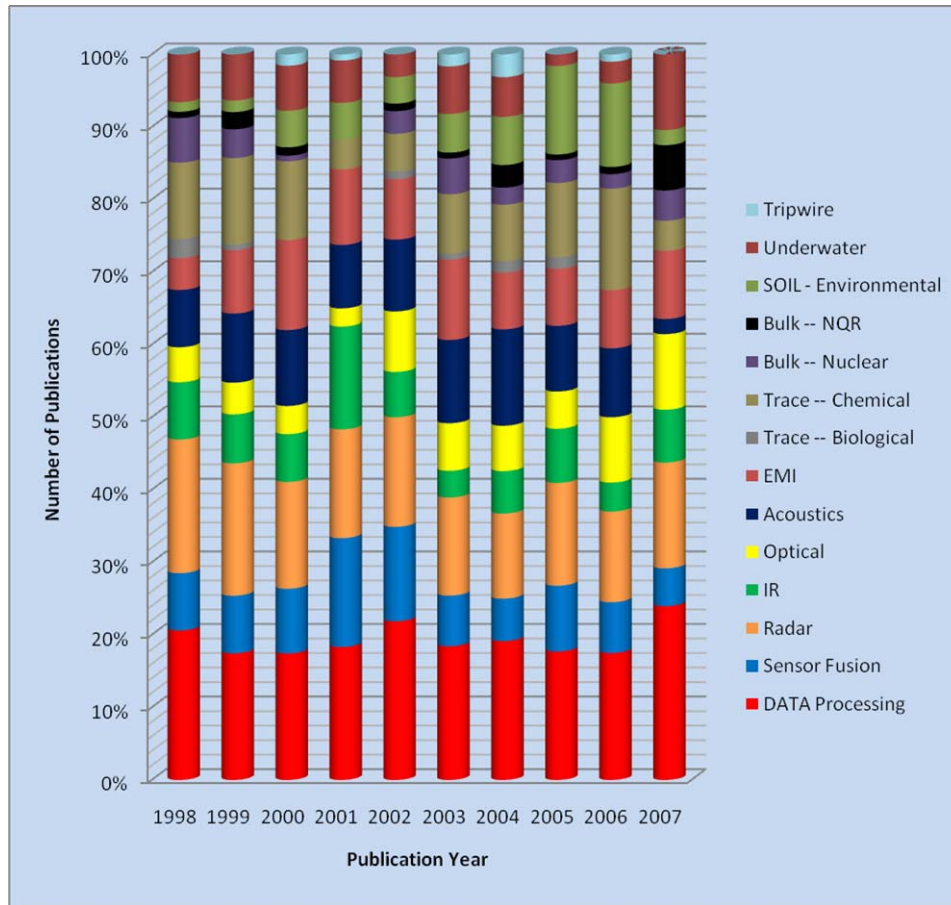


Figure 4-2 Relative number of SPIE proceedings publications per category

The subdivision into categories was done based on the title and abstract contents rather than on the original editorial subdivision¹⁸. If a paper belonged to two categories, it was counted as half for both categories. Poster papers were also counted using this method. Some papers which fell totally outside the predefined categories were not counted (e.g. papers describing test facilities, or personal protective equipment, etc), which explains why the annual total number of publications in Figure 4-1 can be slightly smaller than the official one reported in Figure 4-3. The latter provides an idea of the evolution of the total number of papers over time.

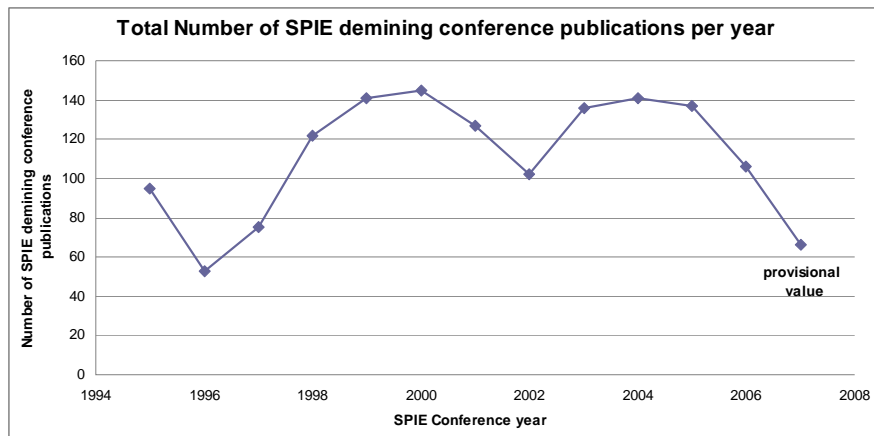


Figure 4-3 Total number of SPIE conference publications per year

¹⁸ Differences with respect to the original classification are usually minor, with the possible exception of soil/environmental related publications, which might have been classified in other categories such as the particular sensing technology being addressed.

4.2 Conclusions

The evolution of the total number of publications shows a clear rise in the mid-'90s, an almost constant number until 2005 with a dip in 2002, and what appears to be a decline after 2005. This trend is certainly influenced by the fact that US MoD sponsored University research in this field is obliged to report at SPIE, but is probably of more general validity. When looking at the evolution of the single subject categories, we can conclude the following:

- There has always been an important data processing, sensor fusion and radar component (the three together accounting in certain years for nearly half of all the publications);
- The interest in soil/environmental studies was small at the beginning and has clearly increased over the years;
- The amount of radar oriented publications decreased over the years;
- Infrared based detection showed several peaks over the years and then regressed strongly;
- Bulk detection is small compared to Trace detection throughout, with the latter becoming more important lately.

Most of these results look again applicable as well to demining R&D carried out in Europe, with the possible exception of the last one (demining related trace explosive detection has not been sponsored in Europe to the extent that it was in the US, e.g. with DARPA's "Dog's Nose" programme).

5 GAP TO MARKET - SUCCESS CASE STUDIES

In this section will illustrate how it is possible to bridge, at least partially, the gap to market with the help of four selected case studies.

5.1 UK – MINEHOUND dual sensor

Description

The MINEHOUND dual sensor detector combines ground penetrating radar (GPR) and a pulsed metal detector to reduce the false alarm rate normally encountered by metal detectors. This is expected to result in improved productivity of mine clearing operations. The output to the operator from both the metal detector and GPR is by means of audio signals.

MINEHOUND is based on a custom-designed GPR from ERA Technology Ltd (UK) and on the pulse induction MD-Type VMH3 from Vallon GmbH (Germany); it is now in production and available from Vallon (MINEHOUND VMR2). The original development (called MINETECT) was developed under the sponsorship of the UK Department for International Development (DFID) and MINEHOUND was additionally supported by the German Foreign Ministry [BRU2006].

According to the manufacturer, trials in live minefields show that the FAR can be reduced by a factor of between two and seven times with respect to a standalone MD, and the GPR also detects zero or minimum metal mines that are difficult for the MD. Full details are reported for example in [BRU2006, and references contained therein].

A number of trials have been completed over the years, including field trials in real minefields in collaboration with several NGOs, alongside the currently used MD and under ITEP invigilation [ERA2006].

Success factors

- A number of funding sources have been exploited over the years (including related GPR developments), both civil and military (European Commission within the DREAM and INFIELD projects for ERA and the HOPE project for Vallon, DFID, UK MoD, the German Foreign Ministry, etc.).
- Constant focus and dedication (continuity).
- Early GPR experience (both as ERA in the Falkland Islands project, 1984-1986, and separately on commercial applications).
- ERA kept visible and continued to communicate and disseminate information throughout.
- Operational experience with GPR products (parallel commercial developments and application line¹⁹, e.g. for civil engineering applications – see also the UK timeline).
- Clear vision of end user requirements and acceptance and potential market (maybe not from the beginning but earlier than others).
- Abandoned an imaging-based approach, targeting the development of a “simple” acoustic interface.
- Commercial awareness (internal ERA investments) and focus on delivering a commercial product.

¹⁹ ERA was selling GPR systems from about 1989 onwards.

5.2 Japan – Equipment Field Tests

Description

Full details of the Japanese projects have already been reported in the corresponding national section.

Success factors

Concentrating on the sensor specific part of the project, we can say that the project has been a success in the sense that:

- It has been possible, by a concerted effort, to bring a number of systems to the field test phase, to scientifically evaluate their detection performance comparing it with currently used metal detectors, and publish the results.
- Three dual-sensor systems were tested under the use of local deminers in Cambodia.
- ALIS will undergo a comparative test by ITEP, in Croatia during Sept. 2007, together with HSTAMIDS (US) and MINEHOUND (UK/Germany). ALIS also underwent validation test in Croatia and Egypt.
- A pre-production version of ALIS will be available at the end of the JST project.
- Scientists have got a good feeling for the actual field conditions.

Actual deployment

It comes as no surprise that actual system deployment has been more successful for the mechanical systems than for sensor equipment.

Concerning the ALIS system in particular, time will tell if its imaging approach will stand a chance compared to the acoustic feedback approach of the competing HSTAMIDS and MINEHOUND systems, which are likely to have profited from more extensive financial backup and longer development time.

5.3 The Netherlands – Spin-offs

5.3.1 Polarisation camera

Description

As a case study the development of a polarisation camera for detection of surface laid man-made objects will be analysed in this section. The development of this technique was done at TNO in the period from 1998 to 2006 (for technical details see also [BRU2006]).

The development of the polarisation technique started in 1998 with some preliminary experiments. In 1999 a PhD student started in this field. The fundamental work provided a good theoretical understanding of the technique. Parallel to the theoretical work laboratory and outdoor experiments provided practical experience with the technique and understanding of the practical limitations. This work was sponsored by basic research funding within TNO.

Based on the results of this study TNO took the lead to submit a proposal for the development of an infrared polarisation camera under FP5. Unfortunately this proposal (POLAMIDE) was not successful.

In 2001 the technique was sufficiently mature to start the development of a product. The first step of this process was the development of a demonstrator. The Netherlands Ministry of Defence (MoD) sponsored this project from a budget dedicated to Humanitarian Demining. The project sponsor within the MoD insisted on the involvement of a demining organisation in the discussion on the requirements for the system. This was one of the lessons learned from a previous larger technology project for Humanitarian Demining sponsored by the MoD. In an effort towards national co-ordination, a demining organisation was contacted which had a good (sponsor) relation with The Netherlands. The Netherlands Ministry of Foreign Affairs (Department of Development Aid) facilitated the contacts with HALO Trust, which was the organisation to be involved. There was no financial involvement of the Ministry of Foreign Affairs.

Another important lesson learned at that time was the issue of affordability of the technology. For this reason the focus of the project changed from using an infrared camera to a cheaper visible light camera. The fact that a visible light camera can only work under good ambient light conditions is acceptable for Humanitarian Demining, whereas the military user would put more value on operations during night time.

The project goal was to develop a camera for support of mechanical area clearance. A critical factor in the process of defining the project goal was that the technical representative of the Humanitarian Demining organisation was able to understand the potential of the technique and at the same time the researcher could understand the operational requirements.

The concept of operation is that the mechanical roller system is used to find a line of AT mines in a suspected area. The concept is adopted from the procedure HALO Trust uses for the detection of anti-personnel mines in suspected areas. The vehicle with the roller in front enters a terrain until a mine is detected: when the roller system encounters a mine, this mine will be detonated and this position is marked as the border of the mine field. The vehicle moves backwards and repeats the procedure at some distance. In this way the contours of the mine field can be probed. The system is designed to survive the explosion of anti-personnel mines without the necessity for repairs of damage. When this procedure is to be used for the detection of anti-tank mines the system has to be designed more robustly. Despite the fact that the roller system is then designed to survive the AT mine detonation, the system will suffer severe damage, which has to be repaired at the cost of time and money. The role of the polarisation camera in this concept is to detect AT mines before they detonate, thus avoiding the system repairs.

This provided a clear concept of operation. In this concept the introduction threshold for the technology is relatively low. When the camera is successful in detecting a mine money and time for repairs will be saved. When the camera detection fails the effects are not fatal, the system will survive. The idea of introducing the system in this way is that there is no need to test the camera system to near 100% detection. Testing to this level would be unrealistic. This concept lowers the threshold for introduction. After introduction of the camera in operation, confidence in the technique can be built up.

Unfortunately HALO Trust decided to stop the development of the AT roller route clearing system because of problems in the roller components, but at the end of the project (2004) a demonstrator camera was available to demonstrate the technique. The public project report has been made available on the ITEP website.

In the meantime military users became interested in the camera system and projects were started which resulted in demonstrations of the technique in a relevant military road clearing scenario. Two tests were performed in 2005 in The Netherlands and one test in 2006 in Germany. All these tests were in a military context. The June 2006 test did show very good results in road clearance scenarios.

Success factors

- 1) Solid scientific understanding of the technique and its limitations based on theoretical work and indoor and outdoor tests, before being obliged to demonstrate the technique in the field (PhD study).
- 2) Involvement of the end-user at the right time, which was enabled by the stakeholders (Netherlands Ministry of Defence and Netherlands Ministry of Foreign Affairs, Dept. of Development Aid).
- 3) Communication with end user at the right level: the technical representative understood the possibilities of the technique, and the researcher understood the operational issues.
- 4) Clear concept of operation. This provided a good basis for technical requirements for the camera system.
- 5) Low threshold of introduction. The technique does not interfere with operational procedure and failure is not fatal, while significant savings can be made when the system works.
- 6) Support from MoD budgets continuously. A business case based on sales for Humanitarian Demining alone would not have been financially attractive.

5.3.2 Development of GPR technology**Description**

The development of this technique was carried out at IRCTR (Delft University) in the period from 1997 to 2006²⁰. The work was done in a cluster of projects, with the main project being "Advanced Re-Locatable Multi-Sensor System for Buried Landmine Detection". The project was funded by the Dutch Technology Foundation STW with additional financial support provided by the Netherlands Ministry of Defence. The University did also contribute to the project. The project was granted in 1998 for 2 years (Phase I) and started in April 1999. After successful completion of Phase I, the project was extended for another two years (Phase II) in April 2001. This 4-year project covered a variety of research activities aimed at improving landmine detection with Ground Penetrating Radar (GPR). The underlying concept is to use multiple microwave sensors in combination with novel imaging, inversion, data fusion and classification schemes to increase detection probability and decrease the number of false alarms. The project is divided into three parts:

- Part 1 comprises the design and realization of two re-locatable imaging GPR systems: an ultra-wideband fully-polarimetric video impulse radar and a stepped frequency continuous wave (SFCW) radar. High resolution data of the subsurface will be acquired with this multi-sensor system and detectability will be assessed systematically.
- Part 2 comprises the development of accurate electromagnetic modelling methods, high resolution 3-D image reconstruction, robust signal and image processing in combination with experimental verification. The processing schemes will be evaluated, verified and modified on the basis of outdoor measurement campaigns.
- Part 3 comprises the development of multi-sensor data fusion (MSDF), feature extraction and object classification methods and algorithms.

The prime goal of the Dutch Technology Foundation STW is to increase the technology base in The Netherlands by funding research projects mainly at (technical) universities. However, it is an obligation of the project manager to pursue the application of the technology developed in these projects. Benefits from licenses on the technology will flow partially back to STW.

In the second phase of the STW project the technology was tested in a controlled outdoor environment (at TNO) available to the researchers. This was a significant step to bring the technology towards a fieldable system. At that point many engineering issues became apparent. Many universities did not take this step and only demonstrated the technology in laboratory conditions.

²⁰ See also the IRCTR website at <http://www.irctr.tudelft.nl/>

After finalising the main STW project the Ministry of Defence sponsored a study to investigate possibilities for the actual further development of the technology into a fieldable system. This funding came out of a budget line dedicated to Humanitarian Demining. As a result of this study a GPR company became interested, with the intention to use the technology developed by IRCTR-TU Delft to jointly develop and build a full scale GPR array.

From the same budget source the Netherlands Ministry of Defence did then sponsor the development of a mini-array for further demonstration of the technology. This mini-array with a limited number of elements will be representative of a section of the full array and will be available for demonstration purposes of the capabilities to be expected from a full scale array. The aim is to allow real-time processing on the data. This array is now (early 2007) available for testing in a controlled outdoor environment. Tests are planned in 2007 in the framework of the military countermine programme.

Success factors

- 1) Solid understanding of the GPR techniques and its limitations before being obliged to demonstrate the technique in the field (several PhD theses resulted from the project).
- 2) Continuous financial support from MoD, STW and University budgets. The project managers had to put in serious efforts to keep the support continuous. Only after significant investments the technology became of interest for a commercial company. A business case based on sales for Humanitarian Demining alone would not have been financially attractive.
- 3) Awareness of operational requirements among others resulting from the tests of the GPR technology in a controlled outdoor environment.

6 GENERAL CONCLUSIONS

This document summarized the analysis of the Humanitarian Demining RTD situation from early 1990 until today. Four European countries (Belgium, Germany, The Netherlands and the United Kingdom) were selected together with Japan. The situation at the European level was also analysed, with emphasis on activities sponsored by the European Commission.

From the analysis, the following findings emerge:

- Humanitarian Demining activities started in earnest during the late '80s-early '90s and soon made the headlines thereafter. As one of the consequences important RTD efforts were started, including a strong EC R&D civilian programme.
- Different countries replied in very different ways (research fragmentation at the European and national level - fragmentation aspects are discussed in D4.2 – "Humanitarian Demining R&D Lessons Learned").
- In a number of cases there has been little interaction between decision makers, R&D organisations and/or end users.
- As with many other "new" topics all involved actors had to climb their share of the learning curve, new structures and ways of collaborating had to be invented (e.g. the International Test and Evaluation Programme, ITEP), with mixed success.
- Examples of coordinated *end-to-end planning* by creating coherence between (1) policy, based on political decision, (2) RTD, testing and production of equipment, and (3) timely deployment, supported by a well organised and co-ordinated organisational structure, showed effectiveness in bridging the gap between R&D and Deployment.
- From the review of the EC R&D projects it appears that, at the current funding/project size, the typical timeframe of 2-3 years is very short for R&D projects, which include a requirements phase, a specification phase, development and integration, demonstrator building, laboratory testing and initial field tests by end users, to be effective. Currently the timeframe for R&D is not sufficiently synchronised with the timeframe of Humanitarian Action funding/operation.
- At the humanitarian demining sensing related R&D level, the most notable developments which have taken place during the past 10 years are: "(i) an increased understanding of the problem, (ii) a shift from a focus on the individual sensor as a solution towards the individual sensor as part of a set of tools, (iii) an increased emphasis on area reduction and the detection of minefield indicators rather than individual mines, (iv) an increased emphasis on trace explosive detection, (v) the gaining of importance of systematic test and evaluation (in particular via the International Test and Evaluation Programme, ITEP)" [BRU2006].
- Although a host of physical principles have been investigated to detect landmines, only electromagnetic-based technologies, in particular enhanced metal detectors and ground penetrating radars, have seen significant advances and are being introduced into the field. Test results consistently confirm that some of these technologies can indeed increase the productivity of humanitarian demining, while at least maintaining the current high levels of safety. Several development groups have shown this is the case for the combination of a metal detector with ground penetrating radar.
- Well known demonstrator systems developed using Earth Observation techniques (e.g. the DG Development Pilot project: Airborne Minefield Detection in Mozambique, and the DG IST ARC & SMART projects) have been sufficiently demonstrated, together with their cost/benefit potential; however, their take-up by end users has not been successful.

- Information Technology, including GIS, has been demonstrated in several European projects (e.g. the DG IST ISIS “Intelligent Systems for Humanitarian Geo-Infrastructure” project, and the DG Development MINEDEMON “Mine Database Demonstrator” project), as well as national projects (RMA-Belgium Paradis). However, the deployment of such systems for field use has been achieved by the GICHD with its Information Management System for Mine Action (IMSMA)²¹, and by the Swedish EOD and Demining Centre (SWEDEC)²² with its EOD IS system, using the end-to-end planning approach mentioned above.
- At the R&D level the subject started to lose importance as from around 2004, being mostly taken over by security related issues and environmental risk management as a whole. The current reduction of the EU Humanitarian Demining research programme and its incorporation into the wider “Improving Risk Management” strategic objective, which was foreseen as a way of generating synergies with other types of responses to humanitarian crises management, where technologies such as Information Management, Geographical Information Management and Earth Observation are more likely to be used in a ‘System Approach’, did not generate the expected synergies.
- Military R&D efforts are still ongoing, although refocused around specific topics (e.g. MMSR-SYDERA in Germany), and likely to continue for the foreseeable future.
- On the civilian front some individual, mostly academic efforts are still ongoing at national level, whereas large concerted projects are ending – like for European projects – and might not be continued.
- Mine Action funding is mostly levelling off, including at EC level, but not decreasing and still substantial [ICBL2006, pp. 64-72].

²¹ <http://www.gichd.org/operational-assistance-research/information-management/overview/>

²² <http://www.eodis.org/>

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7.2 Selected List of Links

In addition to the previous bibliography, we used the following selected list of links in the compilation of the Deliverables.

- o European:

EuropeAid: [Office de coopération EuropeAid](#)

http://ec.europa.eu/comm/dgs/europeaid/index_fr.htm

[EuropeAid - Anti Mines](#)

http://ec.europa.eu/europeaid/projects/mines/documentation_en.htm#pub_eur_comm

[EuropeAid - Who does What](#)

http://ec.europa.eu/europeaid/projects/mines/whodoeswhat_en.htm

Eur-Lex: [Eurlex](#)

<http://eur-lex.europa.eu/en/index.htm>

[The Institutions' registers](#)

<http://eur-lex.europa.eu/en/editorial/registre.htm>

DG RELEX: [The EU and anti-personnel landmines challenge - Overview](#)

http://ec.europa.eu/comm/external_relations/mine/intro/index.htm

[The EU and anti-personnel landmines challenge - Useful Links](#)

http://ec.europa.eu/comm/external_relations/mine/intro/links.htm

- o European, FP Calls (historical):

[CORDIS IST Calls for Proposals IST 3rd Call launched on 10 February 2000](#)

<http://cordis.europa.eu/ist/calls/200001.htm>

[CORDIS IST Calls for Proposals](#)

<http://cordis.europa.eu/ist/calls/calls.htm>

[Welcome to the home page of the Esprit Programme](#)

<http://cordis.europa.eu/esprit/>

[CORDIS FP6](#)

http://cordis.europa.eu/fp6/dc/index.cfm?fuseaction=UserSite.FP6ActivityCallsPage&ID_ACTIVITY=124

- o European, other:

EUDEM2 project: <http://www.eudem.info/>

JRC Projects: [JRC Project Knowledge System - 2005](#)

http://projects.jrc.cec.eu.int/show.gx?Object.object_id=PROJECTS0000000000001746A

- o International:

ITEP: <http://www.itep.ws/itep1.html>

DELVE

Restructuring Demining rEsearch from RegionalL initiatives within Europe

GICHD: <http://www.gichd.ch/>

o National, Germany:

[Federal Foreign Office Humanitarian mine action – aid projects promoted by the Federal Foreign Office](#)

<http://www.auswaertiges-amt.de/diplo/en/Aussenpolitik/FriedenSicherheit/Abruestung/HumanitaeresMinenraeumen/Minen-AA-humHilfe.html>

[BMBF Sicherheitsforschung - Forschung für die zivile Sicherheit](#)

<http://www.bmbf.de/de/6293.php>

o National, Japan:

[JST Home of Research and Development for Humanitarian Demining](#)

<http://www.jst.go.jp/kisoken/jirai/EN/index-e.html>

o National, Belgium:

<http://www.sic.rma.ac.be/Projects/>

<http://www.etro.vub.ac.be>

o National, The Netherlands:

IRCTR: <http://www.irctr.tudelft.nl/>

o National, UK:

[ReliefWeb DFID Background Briefing Humanitarian mine action](#)

<http://www.notes.reliefweb.int/w/rwb.nsf/d2fc8ae9db883867852567cb0083a028/88ef04722490e628c12569900057e497?OpenDocument>

o National, US:

[The World's Landmine Problem and the U.S. Humanitarian Demining Program A Timeline](#)

<http://www.state.gov/t/pm/rls/fs/22182.htm>

[Milestones in Humanitarian Mine Action](#)

<http://www.state.gov/t/pm/rls/fs/22948.htm>

[Milestones in Humanitarian Mine Action Emergence of the Global Landmine Threat, Evolution of Landmine Policy and Development o](#)

<http://www.state.gov/t/pm/rls/fs/58255.htm>

o Other:

SPIE: http://spie.org/x1636.xml?search_text=minelike&category=ProceedingsVolumes

8 ANNEX A – SUMMARY OF DEVELOPMENTS (INDIVIDUAL TECHNOLOGIES)

This section describes the state of the art of the main sensing technologies investigated for Humanitarian Demining applications, some of which are referred to in this document (Source: [BRU2006]).

♦ Individual Technologies and Systems

○ Electromagnetic-based Systems

Metal detectors are definitely better now than 10 years ago (higher sensitivity, improved ergonomic design, man-machine interface and soil signal rejection). Enhanced metal detectors (MDs), for example with discriminatory capabilities, show interesting potential but are still fielded only in small numbers, for example on vehicle-based systems for “wide area detection”.

Ground penetrating radar technology reached the stage of production and intensive testing, and some deployment in the field. These developments did definitely profit from the expertise gained from other applications of GPR (such as non-destructive testing and subsurface sensing), the well known basic theory and limitations, as well as the operational use. Most of the GPR systems being developed or used are combined with metal detectors and employed as confirmatory sensors. Combined MD and GPR systems are nowadays used as hand-held or vehicle-mounted systems. Most of the presented vehicle-based systems are in a stage of testing for applications such as road clearance, and moving from prototype to real production could take a few years for some systems (Japan, US).

○ Trace Explosive Detection

Great progress has been made in this domain, with several systems being tested and available as pre-production units. Rather than the pure performance of the sensors themselves, the main problem seems to lie with their use within an appropriate operational procedure, deciding whether to employ them either as area reduction sensors, or in selected scenarios for confirmation purposes, or still as training or benchmarking tools in combination with mine detection dogs, taking in due account the sampling issue and the influence of environmental parameters. Answers are likely to be forthcoming once there will be a clear commitment from donors and end-users for extensive testing. Much more R&D seems to be appropriate, given the potential impact of this type of systems, such as being able to declare an area free from explosives.

○ Bulk Detection Systems

The possibility of directly detecting a macroscopic amount of material, and possibly of classifying it as explosive, is *per se* quite appealing. In practice two routes have been taken, either by employing radiation capable of penetrating the soil (and the mine case), typically using neutrons and/or X- or gamma rays, or electromagnetic radiation capable of being highly compound specific (nuclear quadrupole resonance — NQR— systems, which present no radiation danger).

A number of problems have been encountered, related for example to the onesided sensor configuration, the reduced amount of explosives in small anti-personnel (AP) mines and/or the depth of anti-tank (AT) mines, and the need for appropriate and often intense (neutron) sources and corresponding detectors to detect the weak and/or complex return signals.

Concerning penetrating radiation systems, no breakthroughs seem to have occurred, although selected applications are possible, such as for the confirmation of AT mines on roads, or for the characterisation of the contents of unexploded ordnance. R&D investments seem to have been substantially reduced in this area. Time will tell if new versions of existing systems, e.g. neutron moderation, will find their way. NQR is still being pursued by a number of research groups, trying in particular to surmount the TNT²³ detection problem for small buried anti-personnel mines, and to quantify exactly the minimum amount of detectable explosive.

²³ Trinitrotoluene, one of the most widely used military explosives, and quite common in landmines.

Significant R&D and test and evaluation seems to be still required to get to a fieldable system, which would however have the great advantage of really being sensitive to a physical parameter characteristic of a mine, i.e. its explosive content (for non-metallic mines).

- **Remote Sensing**

These systems are based on off-the-shelf opto-electronic technologies, ranging from visible to thermal infra-red and multispectral sensors. They have the characteristic that they could be mounted on vehicles, or on airborne platforms, and used for area reduction. Airborne survey in particular is shifting from experimental towards "production survey": a *coherent framework emerges* with opportunities for improvement, both on the sensor (e.g. polarised infrared cameras) and on the software side (e.g. integrated global information system environments, or image interpretation methods). It involves the total use and integration of all available information over an area — aerial and satellite multimodal data, ground surveys, interviews and local knowledge about land use — ranging from small-scale to large-scale, from the past to the present status. The means to obtain all this information are generally known, whereas the integration and structuring schemes are emerging and being validated, often in collaboration with national Mine Action Centres.

- ◆ **Other Detection Principles**

The other detection principles illustrated in [BRU2006], in particular seismoacoustic (which has seen a substantial increase in interest level during the past 10 years), have shown potentially interesting R&D results, which should be turned into test and evaluation criteria. A collaboration between developers and end users would allow to clarify the potential, the operational use as well as the developments to be undertaken.

Increased efforts are also being allocated to better understand the soil influence and environmental limitations, which do represent in many cases the limiting factor. These aspects were unfortunately somewhat neglected in the past.

9 ANNEX B – DELVE DATA BASE AND WEBSITE

The DELVE project website (www.delve.vub.ac.be) and accompanying database (DB) are derived from those produced by the EC EUDEM2 project. Both the structure of the database as well as the layout of the website were adapted and modified to reflect the DELVE requirements, as described in the following. In summary, the following work was carried out:

- DB copy from the EUDEM2 DB to the DELVE DB.
- Modification of Organization types according to the DELVE specifications.
- Modification of the database structure (possibility to add results for projects as well as linking the main donors and end users to the corresponding projects).
- Modification of the intranet pages (used to access and modify the underlying database) to be able to input the new data types.
- Modification of the extranet (pages visible to the external world) to show the new data types with the appropriate format.
- Update/overhaul of the existing data and addition of newly gathered data.
- Addition of static pages with additional project results (previous EUDEM2 organigrams and current associated short textual updates; timelines; DELVE results on the environmental risk management analysis).
- Extensive testing before releasing.

9.1 DELVE Data Base Structure

The database is structured around three main tables containing three main data categories (see the following Figure): *Technologies*, *Organizations* and *Projects*. Each record stored in the database corresponds to one of the above mentioned categories. In order to represent a real world situation, the records are linked, providing a complex framework for storing the data. For example, an organization can be involved in projects, which can furthermore make use of technologies and so on. Each such relation and its particular details are stored as well in the database.

Each main table is linked with the other main tables by means of three other tables that store the relations between objects. The different relations (tables) themselves are organized in three levels: top-level, mid (second)-level, and the third level; these tables are briefly described hereafter.

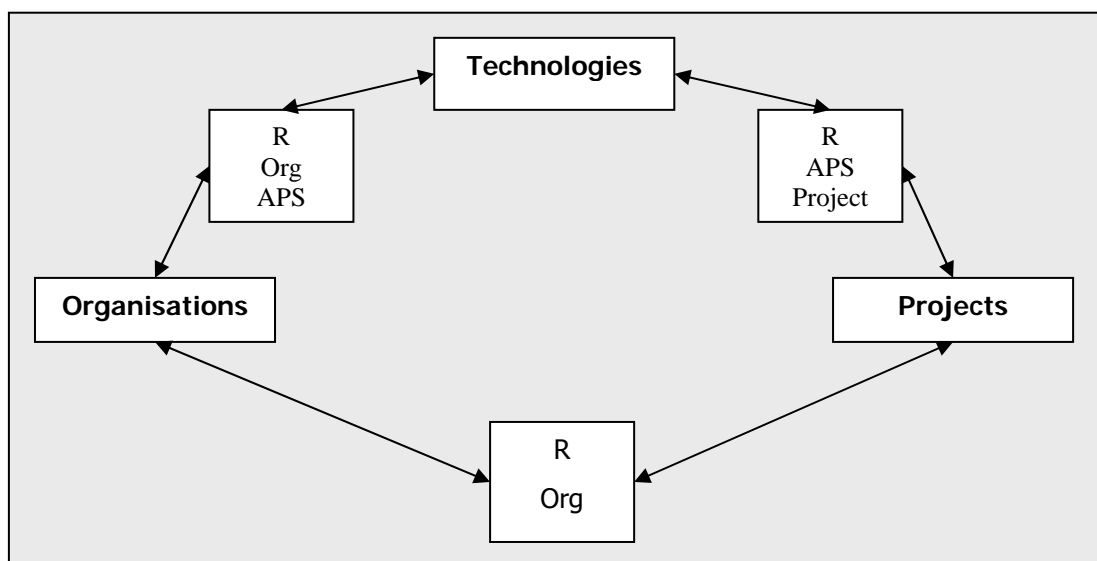


Figure 9-1 Schematic overview of the DELVE Database structure

9.1.1 Top Level Tables

Each record in the three main data categories contains the information about the object it is defining (see previous image). For an *Organization*, its internal ID, name, acronym, type (Donor/Decision maker, R&D Institution—Academia, etc.), address, contact person, website and description are stored. The *Project* category contains the internal ID, name, beginning and ending date, contact person, website and description. Similarly, for a *Technology*, the internal ID, name, description, and website are stored.

9.1.2 Second Level Tables

The three linking tables contain records representing the relation between the main objects. Here an important distinction can be made between the two linking tables connecting to the *Technologies* table (*R_Org_APS* and *R_APS_Project*) on one hand, and the third linking table (*R_Org_Project*) on the other. The latter contains several fields additional to the standard ones, in order to detail for each project not only the organizations involved, but also the sources and results of these projects, whose investigation was one of the DELVE goals.

In order to be able to reflect this new data the following sets of fields were added:

- A first set of fields to reflect the project *results in Humanitarian Demining* (HD). These results are described by a set of keywords (Publications, Demonstrator...) with a possibility of a providing more details for each type of result.
- A second set of fields, similar to the first ones, represents the *results* of the projects towards *non-HD applications*.
- A third and fourth set of fields to store the main *Donor* and main *End User* of the project. This is technically implemented by adding another set of links between the table *T_Org_Project* and the *Organizations* table.

These fields were added at the level of the link between organizations and projects and not directly in the Projects table because the results obtained from a project can be vary greatly from one project partner to another. The Main Donor and Main End User can differ as well from partner to partner.

9.2 DELVE Website

9.2.1 Database Pages

The DELVE website (www.delve.vub.ac.be) provides in first place a set of read-only interfaces reflecting the data in the previously described database. This is done based on three main pages, namely *Projects*, *Organizations* and *Technologies*.

In the *Organizations* page, the European organizations involved in HD are subdivided in the following categories:

- Donors/Decision Makers,
- End Users – Consultancy, HD, Military, Other,
- R&D Organizations – Academia, Defense, SME, Large Industry, Other, and
- Other Organizations.

By clicking on one of the *Organizations* a page detailing all the related information about said organization is retrieved. This includes the organization's name and acronym, its address and main contact person. It also shows the projects the organization is linked to as well as the related technologies. An example is displayed below.

RMA - SIC - Royal Military Academy (Belgium) - Signal & Image Centre (R&D Organizations -- Academia)

Address: Avenue de la Renaissance, 30

Postal Code: B-1000

City: Brussels

Country: Belgium

Contact Person: Marc Acheroy (Professor-Director)

Telephone: +32 27 37 64 70

Fax: +32 2 737 6472

Web Site: <http://www.sic.rma.ac.be>

The Signal and Image Centre (SIC) is a research group associated with the Electrical Engineering Department of the Faculty of Applied Sciences of the Royal Military Academy.

Related Projects:

- HOPE (Hand-held Operational Demining System)

Contact Person: Pascal Druyts

Web Link: <http://www.sic.rma.ac.be/Projects/Hope/>

Details:

Other contact person: Yann Yvinec

SIC (Signal and Image Centre) works on the processing from the signals and images from the three sensors and the fusion on these data.

Primary Demining Result: *Publications*

Secondary Demining Result: *Demonstrator. A hand-held demonstrator of a ...*

Tertiary Demining Result: *Test Facilities*

Project Main Donor: *Directorate General for Industry*

Figure 9-2 Example of record display with its relations with other records

The previous figure shows part of the detail page for the RMA Belgium (only one project has been selected). Note that only results related to demining are shown here - in all the web pages entries which are empty (as the non-demining results in this case) are indeed omitted. The project main donor is displayed with a link to the detail page of that organization. The same goes true for the project main end user if available.

The second main page is the *Projects* page, where the projects are listed by their main funding source, i.e. national or EC funded projects. When clicking on the project link again an explanatory page is retrieved with the project details and the list of involved organizations and technologies. An example of such a project explanatory page is displayed below.

DIAMINE - Detection and Imaging of Antipersonnel Landmines by Neutron Backscattering (EC Funded Projects)

Start Date: 1 January 2001

End Date: 31 December 2003

Budget: 2.798.770 euro

Contact Person: Daniele Galimberti

Web Link: <http://www.tn.infn.it/explodet/rep2001.HTML/>

EC Contribution to the budget: 1.700.000 euro

Project Abstract:

The project proposal is to build and in-field test a novel smart system for entirely plastic antipersonnel landmine detection, based on the neutron backscattering technique. The system will provide minimum hazard, very simple human interface, and the capability of imaging APL.. The integration of this system with a modified Metal Detector will be studied, and a final prototype with the two sensor heads will be prepared and tested.

Objectives:

The objective of DIAMINE is to develop a prototype of hand-held landmine detector using the neutron back-scattering technique. A low-activity source (^{252}Cf , about 10^5 fast neutron/second) will irradiate the soil. The yield of low-energy back-scattered neutrons depends on the quantity of hydrogen in the illuminated volume. The presence of land-mine causes a localised and strong increase of the yield. The comparison of the instantaneous count-rate with other parameters acquired on-line (source-soil distance and previous yield values due only to soil moisture) will be used to automatically detect the presence of a localised anomaly, giving a simple message to the operator. In some conditions, the hits distribution of the detector will provide an "image" of the hidden object, which will drastically lower the false alarm rate. Validation tests in laboratory and in-field are planned. The coupling with a Metal Detector will be carried out and tested. The use of such detectors vehicle mounted system will be also explored.

Description of the Work:

The DIAMINE project is supposed to run without gaps, in a unique phase, in recognition of the urgent need to make new tools available to Humanitarian De-mining operators. First a Monte Carlo simulations of the detector response to neutron back scattering will be performed from a specimen of soil containing a landmine to define detailed performances of the system. At the same time, a position sensitive thermal neutron detector will be developed. Such detector has to work very close to the fast neutron source (^{252}Cf or Am-Be radioactive sources emitting 10^5 neutrons/second) and therefore has to be insensitive to the direct radiation from the source, including the gamma-rays. Furthermore the detectors have to be of light mass and mechanically robust to be employed in field. They have to be radiation resistant and should not require special care in handling to be serviced on site. The neutron detector will be integrated with suitable front-end electronics. Simultaneously, computing and Man-Machine interface will be developed using data from simulations and special Metal Detector (MD) heads. Then they will be studied to allow the integration with the neutron backscattering system (NBS). Finally, prototypes of hand-held systems will be prepared, including MD, NBS heads and ancillary sensors, to determine the detector-soil distance and the scan speed. Information from such sensors will be used to correct on-line the NBS response. The developed hand-held systems will be tested in laboratory as well as in field conditions with real mines. The final tests will be performed at the indoor Rudier Bosovic facility in Zabreb as well as in a test field by a Balkan Mine Action Centre in Croatia. The use of the developed sensors in vehicle mounted systems will also be tested.

Involved Technologies:

- Enhanced Metal Detector
- Neutron Backscatter
- Multi-Sensor Hand-Held Systems

Involved Organizations:

- LABEN S.p.A. (prime contractor)
Contact Person: Daniele Galimberti
- CAEN (Costruzioni Apparecchiature Elettroniche Nucleari S.p.A.)
- INFN (Istituto Nazionale di Fisica Nucleare)
Contact Person: Giuseppe Viesti
- JRC-IRMM (Joint Research Centre - Institute for Reference Materials and Measurements)
- NeuriCam S.p.A.
- RBI (Ruđer Bošković Institute)
- Slovak Academy of Sciences - Institute of Physics
Contact Person: Stanislav Hlaváč
- Vallon GmbH
- W-IE-NE-R, Plein & Baus GmbH

Figure 9-3 Example of project detail display

Finally, the third main page is the *Technologies* page where for each technology used or under investigation a short summary is provided, together with the list of organizations and projects linked to this particular technology.

9.3 Non-Database Pages

Apart from the interface pages which represent the contents of the DELVE database, a number of static pages are available as well. The first of these is the *Organigrammes* page, which displays for some selected countries (F, D, NL, UK, as well as for the EC) a schematic overview of the main organizations, funding bodies and projects related to demining R&D. For those that also have an entry in the DB, a link is provided directly from the organigramme. These organigrammes were created in 2004, and are accompanied by a textual update to the current situation.

The page *Info Ex* contains a list of national and international organizations working in the field of information exchange and standard dissemination around Humanitarian Demining Technologies. These organizations are subdivided into three subcategories, i.e. *General*, *International Organizations*, and *Standards Dissemination*.

Finally, a page on environmental risk management has also been added. Its purpose is to provide a summary and timeline of EU regulation on Environmental Risk Management from 2000 onwards, and an analysis of available EU funding mechanisms in FP6 (2002–2006) and in particular FP7 (2007–2013).

9.4 Intranet

The DELVE intranet has been updated and fully reviewed in order to allow the authors to enter new data and modify the existing entries. This intranet, though not visible to the general public, is an indispensable tool for interfacing with the database in a read/write mode. The intranet consists of several interface webpages, dedicated to one of the tables. The basic structure is similar to that of the extranet in that the main pages show the list of organizations, projects or technologies, with for each the option to select to edit or to remove. When choosing to edit an entry a detail page is shown where all entries are editable. Similar edit pages are available for the connection pages.

10 ANNEX C - UPDATED LIST OF ORGANISATIONS IN THE DELVE DB

1) Donors / Decision Makers

- DFG - Deutsche Forschungsgemeinschaft
- DGA - Délégation Générale pour l'Armement
- EC DG-INFOS - European Commission, Directorate-General Information Society
- EC DG-RELEX - European Commission, Directorate-General External Relations
- EuropeAid Co-operation Office
- Foreign Office of the FRG - Humanitarian Aid
- Government of Finland, Department for Global Affairs, Unit for Humanitarian Assistance
- IAEA - International Atomic Energy Agency
- Ministry of Defence of the Netherlands
- MoD Germany - Ministry of Defence - Germany

2) End Users

2.a) Consultancy

- DEMEX
- RK Consulting
- Threat Resolution Ltd

2.b) HD

- BACTEC - BACTEC International Limited
- BHMAL - Mine Action Center
- CROMAL - Croatian Mine Action Center
- DEMIRA e.V.
- FSD - Swiss Foundation for Mine Action
- Gerbera - Gesellschaft zur Erfassung und Bereinigung von Altlasten mbH
- GICHD - Geneva International Centre for Humanitarian DeminingHALO Trust
- HI - Handicap International
- HLDF - Humanitarian Land-Mine Disposal System Foundation
- MAG - Mines Advisory Group
- MgM - Menschen gegen Minen
- Mineseeeker Foundation
- NPA - Norwegian Peoples Aid
- SRSA - Swedish Rescue Service Agency
- SUA APOPO

2.c) Military

- SEDEE / DOVO (Bomb Disposal unit) Belgian Defence

3) R&D Organisations

3.a) Academia

- Bonn University, Geologisches Institut, Abteilung Angewandte Geophysik
- Chalmers University of Technology - Dept. of Signals and Systems
- CNRS - University of Nice - Sophia Antipolis - Electronics, Antennas & Telecommunications Laboratory
- CSIC - Centro Nacional de Biotecnologia - Dept. Microbial Biotechnology
- Darmstadt Technical University, Institut für Festkörperphysik, Fachbereich Physik
- POLIMI - DEI - Politecnico di Milano - Dipartimento di Elettronica e Informazione
- RMA - Mecatronics - Royal Military Academy - Mecatronics
- RMA - SIC - Royal Military Academy (Belgium) - Signal & Image Centre
- Rostock University, Institut für Allgemeine Elektrotechnik
- RUB DA - Ruhr-Universität Bochum
- Saarland University , Institute for Applied Mathematics

- ENST - Ecole Nationale Supérieure des Télécommunications - Département TSI
- EPFL - Ecole Polytechnique Fédérale de Lausanne -- Swarm-Intelligent Systems Group
- EPFL-LAP - Ecole Polytechnique Fédérale de Lausanne
- ETH EAWAG - Swiss Federal Institute of Technology -- Institute for Environmental Science and Technology (EAWAG)
- ETHZ - Swiss Federal Institute of Technology Zurich - Center for Security Studies and Conflict Research
- Georg-August University Göttingen, Institute for Numerical and Applied Mathematics
- Ghent-IPI - Ghent University - Image Processing and Interpretation Research Group
- IHE - Universität Karlsruhe (TH) - Institut für Höchstfrequenztechnik und Elektronik
- IMEC - Interuniversity Microelectronics Center
- IRCTR - Delft University of Technology-Research Centre for telecommunications-transmission and Radar
- Johannes Gutenberg University Mainz, Research Group Numerical Mathematics
- Jozef Stefan Institute
- Kaliningrad State University
- KCL - King`s College London - Dept. of Mech. Eng
- La Sapienza University Dep. of Electronic Engineering,
- Laboratorio Ultrasuoni e Controlli Non Distruttivi - Università di Firenze
- Military Academy Brno
- NTNU - Norwegian University of Science and Technology
- P. N. Lebedev Physical Institute, The Russian Academy of Sciences
- Slovak Academy of Sciences - Institute of Physics
- Stockholm University - Dept. of Analytical Chemistry
- TU Delft - IRI - Delft University - Interfaculty Reactor Institute
- TU Ilmenau - Technische Universität Ilmenau
- TUG - MEED - Technical University of Gdansk - Department of Medical and Ecological Electronics
- UCL - EMIC - Université Catholique de Louvain - Microwave Laboratory
- ULB - IGEAT - Université Libre de Bruxelles - Institut de gestion de l`environnement et d`aménagement du territoire
- UniGE-PMAR - University of Genova - PMAR Lab
- United Institute of Informatics Problems
- Universität Dortmund, Experimentelle Physik III, Fachbereich Physik
- Universität Karlsruhe (TH), Institute of Mathematics
- University of Bari
- University of Bristol - Dept of Electronic Engineering
- University of Edinburgh - School of Engineering and Electronics
- University, Institut für Geophysik und Meteorologie (IGM), Abteilung Explorationsgeophys
- VUB - ETRO - Vrije Universiteit Brussel - Department of Electronics and Information Processing
- WU - DTU - Warwick University, DTU, School of Engineering

3.b) Defence

- Danish Defence Research Establishment, Institute of Operations Research and Statistics
- DSTL - Defence Science and Technology Laboratory
- FGAN - Forschungsgesellschaft für Angewandte Naturwissenschaften e.V
- FGAN - Research Institute for Optronics and Pattern Recognition
- Norwegian Defence Research Establishment - Division for Protection and Materiel
- SWEDEC - Swedish EOD and Demining Centre
- Swedish Armed Forces Dog Instruction Center
- TNO FEL - Netherlands Organisation for Applied Scientific Research - Physics and Electronics Laboratory
- TNO-PML - Netherlands Organisation for Applied Scientific Research - Prins Maurits

- FOI - Swedish Defence Research Agency Laboratory
- ISL - Institut Franco-Allemand de Recherches de Saint-Louis

3.c) Large Industry

- BGT - Bodenseewerk Geraetetechnik GmbH
- Bofors
- CAC Systemes
- CNIM
- Daimler Chrysler
- EADS SODERN
- ERA - ERA Technology
- GTD - Ingenieria de Sistemas y de Software SA
- Hydrema
- IABG mbH
- Kayser-Threde GmbH
- LABEN S.p.A.
- Lindauer DORNIER GmbH
- MaK - MaK Systems GmbH
- MS&I - EADS MATRA Systemes & Information SA
- Patria Vehicles Oy
- QinetiQ
- RLS - Rheinmetall Landsysteme GmbH
- SBUS - SAAB Bofors Underwater Systems A.B.
- STE - SaabTech Electronics AB
- STN ATLAS Elektronik GmbH
- Technopol j.s.c.
- Thales Airborne Systems
- Thomson Marconi Sonar SAS
- TLG - The Lightship Group - European Office
- Trasys SA
- YXLON International x-ray GmbH

3.d) SME

- 3d-Radar AS
- Aardvark - Aardvark Clear Mine Ltd
- AEL - Fluid Gravity / Applied Electromagnetics
- ARESA
- BAAB - Biosensor Applications Sweden AB
- BATS - Belgian Advanced Technology Systems
- CAEN - Costruzioni Apparecchiature Elettroniche Nucleari S.p.A.
- CEIA - Costruzioni Elettroniche Industriali Automatismi
- Digger DTR, Demining Technologies
- DISARMCO
- Dok-Ing d.o.o.
- Ebinger
- EMRAD
- EPPRA sas
- G2 Ingenjorsbyrå AB
- GEOSPACE - GEOSPACE Beckel Satellitenbilddaten GmbH
- Guartel Technologies LTD
- HarbourDom GmbH
- Humanity Dog, Hundskolan
- IXL - IXL Satelliteninformations-Aktiengesellschaft
- IXTREM
- JAFO Technologie
- JCS - John Caunt Scientific Limited
- Krohn
- M-Detect
- MEODAT - MEODAT Messtechnik, Ortung und Datenverarbeitung GmbH
- MIT - Magnetic Imaging Tools GmbH
- NeuriCam S.p.A.
- PLBRAKE
- RST AG - Radar Systemtechnik AG
- SATIMO
- Schiebel Elektronische Geraete GmbH
- SPACEBEL S.A.
- T&A Survey BV
- TRICON Geophzisk und Systemtechnik GmbH
- Vallon GmbH
- W-IE-NE-R, Plein & Baus GmbH
- WAY INDUSTRY a.s.
- X-TECH - X-Technologies

- IDS - Ingegneria dei Sistemi SpA
- Institut Dr. Foerster
- IUT - Institut für Umwelttechnologien GmbH

- Zeman
- Zeppelin Luftschifftechnik GmbH

3.e) Other

- AIST - National Institute of Advanced Industrial Science and Technology (Japan)
- APS - European Centre of Mechatronics
- BGS - British Geological Survey
- CUTEC Institut GmbH, Clausthal-Zellerfeld
- DLR - Deutsches Zentrum für Luft- und Raumfahrt e.V.
- Fraunhofer Institute for Manufacturing Engineering and Automation (IPA)
- Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (IZFP), Saarbrücken
- Gesellschaft für Schwerionenforschung -- Gamma-ray Spectroscopy Group
- ICT - Fraunhofer Institut Chemische Technologie
- INFN - Istituto Nazionale di Fisica Nucleare
- INOE
- Institut für Geowissenschaftliche Gemeinschaftsaufgaben (GGA)
- JRC - EMSL - Joint Research Centre - European Microwave Signature Laboratory
- JRC HSU - Joint Research Centre - Humanitarian Security Unit
- JRC-IRMM - Joint Research Centre - Institute for Reference Materials and Measurements
- ONERA CERT - Office National d'Etudes et de Recherches Aérospatiales - Centre de Recherche Toulouse
- RBI - Ruđer Bošković Institute
- RSLab - Remote Sensing Laboratory
- V.G. Khlopin Radium Institute

4) Other Organisations

- CH Disc - Swiss-based Land Mine Discussion Group
- IGEO - Intergalactic EOD and Demining Foundation
- PRIO - International Peace Research Institute
- WADEM Landmine Taskforce

5) Non-European Organisations

- Amtech Aeronautical Limited
- ATC - U.S. Army Aberdeen Test Center
- Atomic Energy Organisation of Iran, Nuclear Research Centre
- Barringer
- BEI - Brooks Enterprises International, Inc.
- Canadian Sensors & Software Inc.
- Carleton University
- CCMAT - Canadian Centre for Mine Action Technologies
- CECOM - U.S. Army Communications-Electronics Command
- Center for Applied Biomechanics - University of Virginia
- Concurrent Technologies Corporation / National Defense Center for Environmental Excellence
- CORTEX Engineering LTD.
- CSSIP - University of Queensland - Centre for
- MREL Specialty Explosive Products Limited
- National Demining Operations office Lebanon
- Niagara Prosthetics and Orthotics Ltd.
- NMT - New Mexico Tech (New Mexico Institute of Mining and Technology)
- Nomadics Inc.
- Northeastern University
- NVO - Night Vision Operations Laboratory
- ODI - Ordnance Disposal International
- ORNL - Oak Ridge National Laboratory
- OSU - Ohio State University - ElectroScience Laboratory
- PE - Pearson Engineering LTD
- Penetradar Corporation
- POLDICAM
- PRO MAC Manufacturing Ltd.
- QM - Quantum Magnetics

DELVE

Restructuring Demining Research from Regional Initiatives within Europe

- Sensor Signal and Information Processing
- D-EOD Consulting
- DARPA - Defense Advanced Research Projects Agency
- DEMEX Consulting Engineers A/S
- Demining Network Canada
- DRDC - Defence Research and Development Canada
- DSTO - The Defence Science and Technology Organisation of Australia
- Duke - Duke University - Dept. of Electrical and Computer Engineering
- GIL - Guigne International LTD
- Global Training Academy
- Golden West Products International
- Harvard - Harvard University
- HDP - Office of Humanitarian Demining Programs - U.S. Department of State
- IAI - Israel Aircraft Industries Ltd.
- ICBL - International Campaign to Ban Landmines
- ITRES - ITRES Research Limited
- Johns Hopkins University - Applied Physics Laboratory
- MAIC - Mine Action Information Center at JMU
- Mechem
- Med-Eng Systems Inc.
- Minelab
- MineTech
- MINWARA - The Mine Warfare Association
- Monash University Malaysia - School of Engineering and Science
- MRC - Marmara Research Center
- Queens University
- Queensland University of Technology Brisbane
- Raton Technology Research
- RONCO Consulting Corporation
- Sandia National Laboratories
- Society for Counter-Ordnance Technology
- SPIE - The International Society for Optical Engineering
- Stevens - Stevens Institute of Technology
- Texas A&M University
- Thiokol Propulsion
- U.S. Marine Corps System Command
- UBC-GIF - University of British Columbia - Geophysical Inversion Facility
- University of Florida
- University of Kansas - Department of Geography
- UNMAS - United Nations Mine Action Service
- US Army Research Office
- US K9 - US Tactical K9 Training Academy
- UWA - University of Western Australia - Department of Mechanical and Materials Engineering
- UXOCOE - Unexploded Ordnance Center of Excellence
- Viking Power Dozer
- Western Kentucky University - Applied Physics Institute

Table 10-1 DELVE DB List of Organizations